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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : C12N 15/82, 15/29, A01H 5/00 C12N 5/10	A1	(11) International Publication Number: WO 92/13956 (43) International Publication Date: 20 August 1992 (20.08.92)
(21) International Application Number: PCT/EP92/00274 (22) International Filing Date: 6 February 1992 (06.02.92) (30) Priority data: 91400318.1 8 February 1991 (08.02.91) EP <i>(34) Countries for which the regional or international application was filed:</i> AT et al. 91402590.3 27 September 1991 (27.09.91) EP <i>(34) Countries for which the regional or international application was filed:</i> AT et al. 91403352.7 10 December 1991 (10.12.91) EP <i>(34) Countries for which the regional or international application was filed:</i> AT et al. (71) Applicant (for all designated States except US): PLANT GENETIC SYSTEMS, N.V. [BE/BE]; Kolonel Bourgstraat 106, B-1040 Brussels (BE). (72) Inventors; and (75) Inventors/Applicants (for US only): MICHIELS, Frank [BE/BE]; Jozef Plateaustraat 22, B-9000 Gent (BE). MORIOKA, Sinji [JP/JP]; 700, Higashibara, Toyoda, Iwata, Shizuoka 438 (JP). SCHEIRLINCK, Trees [BE/BE]; Jozef Plateaustraat 22, B-9000 Gent (BE). KOMARI, Toshihiko [JP/JP]; 700, Higashibara, Toyoda, Iwata, Shizuoka 438 (JP).		(74) Agent: ERNEST GUTMANN - YVES PLASSERAUD S.A.; 67, boulevard Haussmann, F-75008 Paris (FR). (81) Designated States: AT (European patent), AU, BB, BE (European patent), BF (OAPI patent), BG, BJ (OAPI patent), BR, CA, CF (OAPI patent), CG (OAPI patent), CH (European patent), CI (OAPI patent), CM (OAPI patent), CS, DE (European patent), DK (European patent), ES (European patent), FI, FR (European patent), GA (OAPI patent), GB (European patent), GN (OAPI patent), GR (European patent), HU, IT (European patent), JP, KP, KR, LK, LU (European patent), MC (European patent), MG, ML (OAPI patent), MN, MR (OAPI patent), MW, NL (European patent), NO, PL, RO, RU, SD, SE (European patent), SN (OAPI patent), TD (OAPI patent), TG (OAPI patent), US. Published <i>With international search report.</i>
(54) Title: STAMEN-SPECIFIC PROMOTERS FROM RICE		
(57) Abstract		
Rice anther-specific promoters which are of particular utility in the production of transgenic male-sterile monocots and plants for restoring their fertility.		

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STAMEN-SPECIFIC PROMOTERS FROM RICE

This invention relates to promoters isolated from rice which can provide gene expression predominantly or specifically in stamen cells of a plant, particularly a monocotyledonous plant, and thereby provide little or no gene expression in other parts of the plant that are not involved in the production of fertile pollen. The promoters are useful in the production of transformed plants, in which a gene is to be expressed at least predominantly, and preferably specifically, in the stamen cells, preferably in the anther cells. The promoters are especially useful in the production of male-sterile plants and male fertility-restorer plants as described in European patent applications ("EPA") 89401194.9 and 90402281.1, respectively (which are incorporated herein by reference), particularly in the production of hybrids of monocotyledonous plants, such as corn, rice or wheat.

Summary of the Invention

In accordance with this invention are provided male flower-specific cDNA sequences isolated from rice comprising the sequences: SEQ ID no. 1, SEQ ID no. 2, SEQ ID no. 3, SEQ ID no. 4 and SEQ ID no. 5 shown in the Sequence Listing. Also in accordance with this invention are provided the stamen-specific, preferably anther-specific, particularly tapetum-specific, promoters of the rice genes corresponding to such cDNA sequences, particularly the promoter PT72 upstream from nucleotide 2846 of SEQ ID no. 6, the promoter PT42 upstream from nucleotide 1809 of SEQ ID no. 7, and the promoter PE1 upstream from nucleotide 2264 of SEQ ID no. 8 shown in the Sequence Listing. These promoters can each be used in a foreign DNA sequence, preferably a foreign chimaeric DNA sequence, which contains a structural gene,

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preferably a male-sterility DNA or a male fertility-restorer DNA, under the transcriptional control of one of the promoters and which can be used to transform the nuclear genome of a cell of a plant, particularly a monocotyledonous plant. Further in accordance with this invention are provided: the male-sterile plant or male fertility-restorer plant which can be regenerated from such a cell transformed with the foreign DNA sequence of this invention; the cells, cell cultures and seeds of such a plant; and the male fertility-restored plant and its seeds resulting from crossing such male-sterile and male fertility-restorer plants.

Detailed Description of the Invention

In accordance with this invention, a male-sterile plant or a male fertility-restorer plant can be produced from a single cell of a plant by transforming the plant cell in a known manner to stably insert, into its nuclear genome, the foreign DNA sequence of this invention. The foreign DNA sequence comprises at least one male-sterility DNA or male fertility-restorer DNA that is: under the control of, and fused in frame at its upstream (i.e., 5') end to, one of the stamen-specific, preferably anther-specific, particularly tapetum-specific, promoters of this invention; and fused at its downstream (i.e., 3') end to suitable transcription termination (or regulation) signals, including a polyadenylation signal. Thereby, the RNA and/or protein or polypeptide, encoded by the male-sterility or fertility-restorer DNA is produced or overproduced at least predominantly, preferably exclusively, in stamen cells of the plant. The foreign DNA sequence can also comprise at least one marker DNA that: encodes a RNA and/or protein or polypeptide which, when present at least in a specific tissue or specific cells of the plant, renders the plant easily separable or

distinguishable from other plants which do not contain such RNA and/or protein or polypeptide at least in the specific tissue or specific cells; is under the control of, and is fused at its 5' end to, a second promoter which is capable of directing expression of the marker DNA at least in the specific tissue or specific cells; and is fused at its 3' end to suitable transcription termination signals, including a polyadenylation signal. The marker DNA is preferably in the same genetic locus as the male-sterility or fertility-restorer DNA. This linkage between the male-sterility or fertility-restorer DNA and the marker DNA guarantees, with a high degree of certainty, the joint segregation of both the male-sterility or fertility-restorer DNA and the marker DNA into offspring of the plant regenerated from the transformed plant cell. However, in some cases, such joint segregation is not desirable, and the marker DNA should be in a different genetic locus from the male-sterility or fertility-restorer DNA.

The male-sterility DNA of this invention can be any gene or gene fragment, whose expression product (RNA and/or protein or polypeptide) disturbs significantly the metabolism, functioning and/or development of stamen cells, preferably anther cells, and thus prevents the production of fertile pollen. Preferred male-sterility DNAs are described in EPA 89401194.9, for example those DNAs encoding: RNases such as RNase T1 or barnase; DNases such as endonucleases (e.g., EcoRI); proteases such as papain; enzymes which catalyse the synthesis of phytohormones (e.g. isopentenyl transferase or the gene products of gene 1 and gene 2 of the T-DNA of Agrobacterium; glucanases; lipases; lipid peroxidases; plant cell wall inhibitors; or toxins (e.g., the A-fragment of diphtheria toxin or botulin). Other preferred

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examples of male-sterility DNAs are antisense DNAs encoding RNAs complementary to genes, the products of which are essential for the normal development of fertile pollen. Further preferred examples of male sterility DNAs encode ribozymes capable of cleaving specifically given target sequences of genes encoding products which are essential for the production of fertile pollen. Still other examples of male-sterility DNAs encode products which can render stamen cells, particularly anther cells -- and not other parts of the plant -- susceptible to specific diseases (e.g. fungi or virus infection) or stress conditions (e.g. herbicides).

The construction of a vector comprising a male-sterility DNA, such as a barnase-encoding DNA, under the control of a rice anther-specific promoter of this invention is most conveniently effected in a bacterial host organism such as E. coli. However, depending on the nature of the male-sterility DNA and the specific configuration of the vector, problems can be encountered due to the expression of the male-sterility DNA in, and the concurrent decrease of viability of, the host organism. Such problems can be solved in a number of ways. For instance, the host organism can be provided, on the same or different plasmid from that containing the male-sterility DNA or even on its chromosomal DNA, with another DNA sequence that prevents or inhibits significantly the effect of the expression of the male-sterility DNA in the host organism. Such an other DNA sequence can encode, for example: an antisense RNA so that the accumulation and translation of the male-sterility RNA is prevented; or a protein (e.g., barstar) which specifically inhibits the gene product of the male-sterility DNA (e.g., barnase; Hartley (1988) J.Mol.Biol. 202, 913). Alternatively, the male-sterility DNA can contain an element, such as a plant intron, which

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will only result in an active gene product in a plant cell environment. Examples of introns that can be used for this purpose are introns of: the transcriptional units of the adh-1 gene of maize (Luehrsen and Walbot (1991) Mol. Gen. Genet. 225, 81; Mascarenhas et al (1990) Plant Mol. Biol. 15, 913), the shrunk-1 gene of maize (Vasil et al (1989) Plant Physiol. 91, 1575), the cat-1 gene of castor bean (Tanaka et al (1990) Nucleic Acids Research ("NAR") 18, 6767), and the act-1 gene of rice (McElroy et al (1990) The Plant Cell 2, 163; PCT publication WO 91/09948).

The male fertility-restorer DNA of this invention can be any gene or gene fragment, whose expression product (RNA and/or protein or polypeptide) inactivates, neutralizes, inhibits, blocks, offsets, overcomes or otherwise prevents the specific activity of the product of a male-sterility DNA in stamen cells, particularly in anther cells. Preferred fertility-restorer DNAs are described in EPA 90402281.1, for example those DNAs encoding: barstar which is the inhibitor of barnase; EcoRI methylase which prevents the activity of EcoRI; or protease inhibitors (e.g., the inhibitors of papain). Other examples of fertility-restorer DNAs are antisense DNAs encoding RNAs complementary to male-sterility DNAs. Further examples of fertility-restorer DNAs encode ribozymes capable of cleaving specifically given target sequences encoded by male-sterility DNAs.

The marker DNA of this invention can be any gene or gene fragment encoding an RNA and/or protein or polypeptide that allows plants, expressing the marker DNA, to be easily distinguished and separated from plants not expressing the marker DNA. Examples of the marker DNA are described in EPA 89401194.9, such as marker DNAs

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which encode proteins or polypeptides that: provide a distinguishable color to plant cells, such as the A1 gene encoding dihydroquercetin-4-reductase (Meyer et al (1987) Nature 330, 677-678) and the glucuronidase gene (Jefferson et al (1988) Proc. Natl. Acad. Sci. USA ("PNAS") 83, 8447); provide a specific morphological characteristic to a plant such as dwarf growth or a different shape of the leaves; confer on a plant stress tolerance, such as is provided by the gene encoding superoxide dismutase as described in EPA 88402222.9; confer disease or pest resistance on a plant, such as is provided by a gene encoding a Bacillus thuringiensis endotoxin conferring insect resistance on a plant, as described in EPA 86300291.1; or confer on a plant a bacterial resistance, such as is provided by the bacterial peptide described in EPA 88401673.4. Preferred marker DNAs encode proteins or polypeptides inhibiting or neutralizing the activity of herbicides such as: the sfr gene and the sfrv gene encoding enzymes conferring resistance to glutamine synthetase inhibitors such as Bialaphos and phosphinotricine as described in EPA 87400544.0.

In order for the protein or polypeptide encoded by the marker DNA to function as intended, it is often preferred to have it produced in the plant cell as a precursor, in which the mature protein is linked at its N-terminal end to another polypeptide (a "targeting peptide") which will translocate the mature protein to a specific compartment such as the chloroplasts, the mitochondria, or the endoplasmic reticulum. Such targeting peptides and DNA sequences coding for them (the "targeting sequences") are well known. For example, if a marker DNA codes for a protein that confers tolerance or resistance to a herbicide or another selective agent that acts on chloroplast metabolism, such as the sfr (or bar)

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gene or the sfrv gene (European patent publication ["EP"] 0,242,236), it may be preferred that such gene also comprise a chloroplast targeting sequence such as that coding for the transit peptide of the small subunit of the enzyme 1,5-ribulose biphosphate carboxylase (Krebbers et al (1988) Plant Mol. Biol. 11, 745; EPA 85402596.2), although other targeting sequences coding for other transit peptides, such as those listed by Von Heijne et al (1991) Plant Mol. Biol. Reporter 9, 104, can be used.

The stamen-specific, preferably anther-specific, promoters of this invention, such as the promoter PT72 upstream from nucleotide 2846 of SEQ ID no. 6, the promoter PT42 upstream from nucleotide 1809 of SEQ ID no. 7, and the promoter PE1 upstream from nucleotide 2264 of SEQ ID no. 8 -- which can be used to control the male-sterility DNA or the fertility-restorer DNA -- can be identified and isolated in a well known manner as described in EPA 89401194.9. In this regard, each of the cDNAs of SEQ ID nos. 1 to 5 of this invention can be used as a probe to identify (i.e., to hybridize to) the corresponding region of the rice genome (i.e., the region containing DNA coding for the stamen-specific mRNA, from which the cDNA was made). Then, the portion of the plant genome that is upstream (i.e., 5') from the DNA coding for such stamen-specific mRNA and that contains the promoter of this DNA can be identified.

The second promoter, which controls the marker DNA, can also be selected and isolated in a well known manner, for example as described in EPA 89401194.9, so that the marker DNA is expressed either selectively in one or more specific tissues or cells or constitutively in the entire plant, as desired, depending on the nature of the RNA and/or protein or polypeptide encoded by the marker DNA.

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In the foreign DNA sequence of this invention, 3' transcription termination signals or the "3' end" can be selected from among those which are capable of providing correct transcription termination and/or polyadenylation of mRNA in plant cells. The transcription termination signals can be the natural ones of the male-sterility or fertility-restorer DNA, to be transcribed, or can be foreign or heterologous. Examples of heterologous 3' transcription termination signals are those of the octopine synthase gene (Gielen et al (1984) EMBO J. 3, 835-845) and of the T-DNA gene 7 (Velten and Schell (1985) NAR 13, 6981-6998). When the foreign DNA sequence of this invention comprises more than one structural gene (e.g., a male-sterility or fertility-restorer DNA and a marker DNA), it is preferred that the 3' ends of the structural genes be different.

In plants, especially in monocotyledonous plants, particularly cereals such as rice, corn and wheat, the expression in accordance with this invention of a marker DNA, as well as a male-sterility DNA or a fertility-restorer DNA, can be enhanced by the presence at one or more, preferably one, appropriate position(s) in the transcriptional unit of each foreign DNA sequence of this invention of a suitable plant intron (Luehrsen and Walbot (1991) Mol. Gen. Genet. 225, 81; Mascarenhas et al (1990) Plant Mol. Biol. 15, 913; Vasil et al (1989) Plant Physiol. 91, 1575; Tanaka et al (1990) NAR 18, 6767; McElroy et al (1990) The Plant Cell 2, 163; PCT publication WO 91/09948). Preferably, each intron has a nucleotide sequence that: is recognizable by the cells of the plant species being transformed (for requirements of intron recognition by plants, see Goodall and Filipowicz (1989) Cell 58, 473; Hanley and Schuler (1988) NAR 16, 7159), is longer than about 70-73 bp (Goodall and Filipowicz (1990) Plant Mol. Biol. 14, 727), and is

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positioned close to the 5' end of the encoded mRNA, particularly in any untranslated leader sequence.

Cells of a plant can be transformed with the foreign DNA sequence of this invention in a conventional manner. Where the plant to be transformed is susceptible to Agrobacterium infection, it is preferred to use a vector, containing the foreign DNA sequence, which is a disarmed Ti-plasmid. The transformation can be carried out using procedures described, for example, in EP 0,116,718 and EP 0,270,822 and Gould et al (1991) Plant Physiology 95, 426-434. Preferred Ti-plasmid vectors contain the foreign DNA sequence between the border sequences or at least located upstream of the right border sequence. Of course, other types of vectors can be used for transforming the plant cell, using procedures such as direct gene transfer (as described for example in EP 0,223,247), pollen mediated transformation (as described for example in EP 0,270,356, PCT publication WO 85/01856 and EP 0,275,069), in vitro protoplast transformation (as described for example in US patent 4,684,611), plant virus-mediated transformation (as described for example in EP 0,067,553 and US patent 4,407,956) and liposome-mediated transformation (as described for example in US patent 4,536,475).

Where the plant to be transformed is rice, recently developed transformation methods can be used such as the methods described for certain lines of rice by Christou et al (1991) Bio/Technology 9, 957, Lee et al (1991) PNAS 88, 6389, Shimamoto et al (1990) Nature 338, 274 and Datta et al (1990) Bio/Technology 8, 736.

Where the plant to be transformed is corn, recently developed transformation methods can be used such as the methods described for certain lines of corn by Fromm et al (1990) Bio/Technology 8, 833 and Gordon-Kamm et al (1990) The Plant Cell 2, 603.

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Where the plant to be transformed is wheat, a method analogous to those described above for corn or rice can be used. Preferably, for the transformation of a monocotyledonous plant, particularly a cereal such as rice, corn, or wheat, a method of direct DNA transfer, such as a method of biolistic transformation or electroporation, is used. When using such a direct transfer method, it is preferred to minimize the DNA that is transferred so that essentially only the foreign DNA sequence of this invention, with its male-sterility or fertility-restorer DNA and any marker DNA, is integrated into the plant genome. In this regard, when a foreign DNA sequence of this invention is constructed and multiplied on a plasmid in a bacterial host organism, it is preferred that, prior to transformation of a plant with the foreign DNA sequence, plasmid sequences that are required for propagation in the bacterial host organism, such as an origin of replication, an antibiotic resistance gene for selection of the host organism, etc., be separated from the parts of the plasmid that contain the foreign DNA sequence.

The Examples, which follow, describe: the isolation and the characterization of the rice cDNA sequences of SEQ ID nos. 1 to 5 of this invention; their use for isolating, from the rice genome, the stamen-specific promoters of this invention, such as the promoter PT72 upstream from nucleotide 2846 of SEQ ID no. 6, the promoter PT42 upstream from nucleotide 1809 of SEQ ID no. 7, and the promoter PE1 upstream from nucleotide 2264 of SEQ ID no. 8; the construction of gene cassettes by the fusion of each of these promoters with male-sterility and fertility-restorer DNAs; the construction of plant transformation vectors from the promoter cassettes; and the transformation of rice, corn and tobacco with the resulting plant transformation vectors.

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Unless stated otherwise in the Examples, all procedures for making and manipulating recombinant DNA were carried out by the standard procedures described in Maniatis et al, Molecular Cloning - A Laboratory Manual, Cold Spring Harbor Laboratory Press, NY (1982), as well as Sambrook et al, Molecular Cloning - A Laboratory Manual, Second Edition, Cold Spring Harbor Laboratory Press, NY (1989). When making plasmid constructions, the orientation and integrity of cloned fragments were checked by means of restriction mapping and/or sequencing.

The sequence identification numbers referred to above and in the Examples are listed below.

Sequence Listing

- SEQ ID no. 1 : cDNA sequence of the T72 gene.
- SEQ ID no. 2 : partial cDNA sequence of the T23 gene.
- SEQ ID no. 3 : cDNA sequence of the T42 gene.
- SEQ ID no. 4 : cDNA sequence of the T155 gene.
- SEQ ID no. 5 : cDNA sequence of the E1 gene.
- SEQ ID no. 6: DNA sequence of rice genomic clone hybridizing to T72 cDNA.
- SEQ ID no. 7: DNA sequence of rice genomic clone hybridizing to T42 cDNA.
- SEQ ID no. 8: DNA sequence of rice genomic clone hybridizing to E1 cDNA.
- SEQ ID no. 9: DNA sequence of plasmid pVE108.

Example 1

Isolation and characterization of anther-specific cDNAs from rice.

For the cloning of cDNAs corresponding to genes which are expressed exclusively, or at least

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predominantly, in anthers of rice, a cDNA library was prepared from poly A⁺ mRNA isolated from immature spikelets (size 1-3 mm), at their developmental stages of carrying microsporocytes before meiosis and in early meiosis, and from anthers isolated from spikelets (size 3-5 mm), at their developmental stages of carrying microsporocytes undergoing meiosis and after meiosis, from the publicly available rice line *Oryza sativa* var. japonica, Akihikari. By means of the Amersham cDNA Synthesis System Plus RPN 1256 Y/Z kit (Amersham International PLC, Buckinghamshire, England), cDNAs were synthesized using reverse transcriptase and an oligo dT primer, according to the directions set forth in the kit for its use.

The cDNAs were cloned in lambda gt10 vector, using the Amersham cDNA Cloning System - lambda gt10 - RPN1257 - kit, in accordance to the directions set forth in the kit for its use. Upon the cDNA libraries thus obtained (21,000 plaques for the anther library; 6,000 plaques for the spikelet library), differential screening was performed by hybridization with: a labelled first strand cDNA probe copied from rice immature anther mRNA and a labelled first strand cDNA probe copied from rice immature spikelet mRNA (developmental stages as above) as positive probes; and a labelled first strand cDNA probe copied from rice seedling leaf and a labelled first strand cDNA probe copied from rice seedling root as negative probes. 97 candidate anther- and spikelet-specific cDNA clones were selected and again screened with labeled cDNA probes derived from mRNA of anthers and spikelets of rice (positive probes) and from leaf, root and basis of spikelets of rice (negative probes). The basis of spikelets are immature rice spikelets (size 3-6 mm) from which the anthers and the top of palea and lemma

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have been dissected away but which contain intact ovaries. 0.2 μ g phage DNA from the 82 candidate clones passing this second selection step was screened for anther-specific expression in a dot blot assay, hybridized with: labelled first strand DNA probes copied from rice immature spikelet mRNA and rice immature anther mRNA (developmental stages as above) as positive probes; and labelled first strand cDNA probe copied from mRNA of rice seedling leaf, rice seedling root, basis of rice spikelet, dry rice seed, rice callus, and axis of immature rice panicle as negative probes (see Table 1). Thus, cDNA clones were identified which hybridize with at least one of the positive probes but for which no hybridization above background was detected with any of the negative probes.

cDNA inserts of 82 candidate clones were purified and hybridized with the collection of 82 candidate clones in order to identify cross-hybridizing and/or overlapping clones. This led to the identification of twenty two anther-specific cDNA clones which show no mutual cross-hybridization and thus are likely to be derived from different genes. Twenty of these clones were shown to correspond to single copy genes in the rice genome (as tested by Southern hybridization; see Table 1) and were subcloned in pGEM2 or pGEM7Zf(+) (PROMEGA, Madison, WI, USA). 0.2 μ g plasmid DNA from the twenty candidate clones was again screened for anther-specific expression in a dot blot assay as described above. Further analysis showed that there were actually only eighteen different inserts, and these inserts were hybridized to Northern blots with 5 μ g total RNA from rice immature anther, immature spikelet, leaf and root. It was confirmed that sixteen out of eighteen clones tested are expressed in rice immature anther and immature spikelet (development

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stages as above) but not in leaf and root. The profiles of twelve of these selected differential clones, for which a partial or whole sequence was determined, are shown in Tables 1A, 1B and 1C. The twelve cloned anther-specific cDNA inserts were called "T146", "E1", "E2", "T34", "T72", "T157", "T149", "T42", "T139", "T155", "T23", and "T118". Five of these anther-specific cDNAs, i.e., the E1, T72, T42, T155 and T23 cDNAs, were further shown to be expressed both before and after meiosis of microsporocytes and also to exhibit strict anther-specific expression in a more sensitive analysis. The best expression level before meiosis was observed for the E1, T72, and T42 cDNAs. Of these three cDNAs, the T72 cDNA seemed to combine best the desired properties of anther specificity, relatively high level of expression, and substantial premeiotic expression.

The partial or whole sequences of the T72, T23, T42, T155 and E1 cDNAs, cloned in the pGEM plasmids, are shown in SEQ ID no. 1, SEQ ID no. 2, SEQ ID no. 3, SEQ ID no. 4, and SEQ ID no. 5, respectively. The cDNA sequence of T72 reveals two open reading frames (ORF) over 330 and over 114 nucleotides.

Example 2

Isolation of the anther-specific genes corresponding to the anther-specific cDNA clones of Example 1 and identification of their anther-specific promoter regions

To isolate the genomic DNA clones carrying the regulatory sequences of the T72, T23, T42, T155 and E1 genes, corresponding to the selected T72, T23, T42, T155 and E1 cDNAs of Example 1 cloned in the pGEM plasmids pT72, pT23, pT42, pT155 and pE1, respectively, a genomic library of rice var. Akihikari was constructed. This was done by partially digesting Akihikari seedling leaf DNA

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with Sau3AI, purifying the 18-22 kb size fraction by a sucrose gradient centrifugation, and cloning in the bacteriophage lambda EMBL3 replacement vector (as described by Frischaufl et al (1983) J. Mol. Biol. 170, 827 and in Pouwels et al (1988) Cloning Vectors - A Laboratory Manual (Supplementary Update), Elsevier Science Publishers, Amsterdam) cleaved with BamHI and EcoRI. The library was screened with each of the whole pT72, pT23, pT42, pT155 and pE1 cDNA clones, and the restriction maps of the corresponding genomic clones were determined.

Corresponding genomic clones which hybridize to pT72, pT23, pT42, pT155 or pE1 are sequenced (Maxam and Gilbert (1977) PNAS 74, 560). Comparison of the sequences of pT72, pT23, pT42, pT155 or pE1 and the genomic clones leads to the identification of the homologous regions. For each of the five genes (T72, T23, T42, T155 and E1), the transcription initiation site is determined by primer extension using reverse transcriptase on mRNA of a rice tissue expressing the gene. A "TATA" consensus sequence box is found upstream of the transcription initiation site in the promoter of each of the five genes. The ATG translation initiation site is determined as the most upstream ATG codon in the translational reading frame of each clone, determined by DNA sequencing, and as the first accessible ATG codon on the mRNA synthesized in rice.

DNA sequences of parts of the genomic clones GT72, GT42 and GE1, hybridizing to pT72, pT42 and pE1 respectively, are shown in SEQ ID no. 6, SEQ ID no. 7 and SEQ ID no. 8 respectively. For each sequence, the TATA box and the transcription initiation site is indicated. In each sequence, a reading frame is identified that

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starts with an ATG translation initiation codon and that overlaps its corresponding cDNA sequence. The promoter region in each sequence is upstream from, and starts just before, the ATG translation initiation codon of the coding sequence. In this regard, the DNA starting from nucleotide 1 and ending with the nucleotide just before the ATG codon can be considered as the promoter region of each sequence. However, it appears that a preferred portion of each promoter region, for providing anther-specific expression of a heterologous coding sequence of interest (such as a sequence coding for barnase or RNase T1), extends only about 1500 to 1700 bp upstream from its ATG codon, and an even smaller portion of each promoter region extending only about 300 to 500 nucleotides upstream from its ATG codon is sufficient for providing anther-specific expression of a heterologous coding sequence. In each promoter region, the untranslated leader sequence, located between the transcription initiation site and the ATG start of translation, is preferred but is not considered essential for the anther-specific expression of a heterologous coding sequence, and the leader sequence can be replaced by the untranslated leader sequences of other genes, such as plant genes.

A 20 kbp genomic Sau3AI fragment was found that hybridized to the cDNA, pT72. A 4.6 kbp EcoRI fragment of this clone, which hybridized to the cDNA, pT72, was subcloned in pGEM2, and the resulting plasmid was designated "pGT72". A total of 3672 bp, upstream from the EcoRI site closest to the 3' end of the region of homology with the pT72 cDNA, was sequenced, and this sequence is shown in SEQ ID no. 6. By means of primer extension, the initiation of transcription was found to be at position 2765 of this sequence. The TATA box is

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presumed to be located between positions 2733 and 2739, while the translation initiation codon is located at position 2846. The sequence upstream of position 2846 can be used as a promoter region, PT72, for the anther-specific, particularly tapetum-specific, expression of a coding sequence of interest. A preferred portion of this promoter region appears to extend from about position 1242 to about position 2845, but the promoter region can comprise the entire sequence between positions 1 and 2845. It also appears that the minimum region which can serve as an anther-specific promoter extends about 300 to 500 bp upstream from position 2846 in SEQ ID no. 6.

Similarly, a genomic Sau3AI fragment (also of about 20 kbp in length) was recovered that hybridized to the cDNA, pT42. A 5 kbp HindIII fragment of this clone, which hybridized to the cDNA, pT42, was subcloned in pGEM2, and the resulting plasmid was designated as "pGT42". A total of 2370 bp, upstream from the HindIII site located within the region of homology with the pT42 cDNA, was sequenced, and this sequence is shown in SEQ ID no. 7. By means of primer extension, the initiation of transcription was found to be at position 1780 of this sequence. The TATA box is presumed to be located between positions 1748 and 1755, while the translation initiation codon is located at position 1809. The sequence upstream of position 1809 can be used as a promoter region, PT42, for the anther-specific, particularly tapetum-specific, expression of a coding sequence of interest. A preferred portion of this promoter region appears to extend from about position 275 to about position 1808, but the promoter region can comprise the entire sequence between positions 1 and 1808. It also appears that the minimum region which can serve as an anther-specific promoter extends about 300 to 500 bp upstream from position 1809 in SEQ ID no. 7.

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Similarly, a genomic Sau3AI fragment (also of about 20 kb in length) was recovered that hybridized to the cDNA, pE1. A 6 kbp PvuII fragment of this clone, which hybridized to the cDNA, pE1, was subcloned in the SmaI site of pGEM2, and the resulting plasmid was designated as "pGE1". A total of 2407 bp, upstream from the PvuII site located within the region of homology with the pE1 cDNA, was sequenced, and this sequence is given in SEQ ID no. 8. By means of primer extension, the initiation of transcription was found to be at position 2211 of this sequence. The TATA box is presumed to be located between positions 2181 and 2187, while the translation initiation codon is located at position 2264. The sequence upstream of position 2264 can be used as a promoter region, PE1, for the anther-specific, particularly tapetum-specific, expression of a coding sequence of interest. A preferred portion of this promoter region appears to extend from about position 572 to about position 2263, but the promoter region can comprise the entire sequence between positions 1 and 2263. It appears also that the minimum region which can serve as an anther-specific promoter extends about 300 to 500 bp upstream from position 2264 in SEQ ID no. 8.

Example 3

Construction of promoter cassettes derived from the anther-specific promoter regions of Example 2

The 5' regulatory sequences, including the promoter, of each of the five anther-specific genes of Example 2 are subcloned into the polylinker of pMAC 5-8 (EPA 87402348.4). This produces vectors which can be used to isolate single stranded DNAs for use in site-directed mutagenesis reactions. Using site-directed mutagenesis (EPA 87402348.4), sequences surrounding the ATG translation initiation codon of the 5' regulatory

sequences of each of the anther-specific genes are modified to create a unique recognition site for a restriction enzyme for which there is a corresponding recognition site at the 5' end of each of the male-sterility and fertility-restorer DNAs (that are to be fused to the 5' regulatory sequences in Example 4, below). Each of the resulting plasmids contains the newly created restriction site. The precise nucleotide sequence spanning each newly created restriction site is determined in order to confirm that it only differs from the 5' regulatory sequences of the corresponding rice anther-specific gene by the substitution, creating the new restriction site.

Example 4

Construction of plant transformation vectors from the promoter cassettes of Example 3 and from the anther-specific promoter regions of Example 2

Using the procedures described in EPA 89401194.9 and 90402281.1, the promoter cassettes of Example 3 are used to construct plant transformation vectors comprising foreign chimaeric DNA sequences of this invention, each of which contains the 5' regulatory sequences, including one of the anther-specific promoters, corresponding to each of the five anther-specific genes isolated in Example 2. The 5' regulatory sequences are upstream of, are in the same transcriptional unit as, and control either a male-sterility DNA (from EPA 89401194.9) encoding barnase from Bacillus amyloliquefaciens (Hartley and Rogerson (1972) Preparative Biochemistry 2 (3), 243-250) or a fertility-restorer DNA (from EPA 90402281.1) encoding barstar (Hartley and Rogerson (1972) supra; Hartley and Sweatn (1973) J. Biol. Chem. 248 (16), 5624-5626). Downstream of each male-sterility or fertility-restorer DNA is the 3' end of the nopaline

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synthase gene (An et al (1985) EMBO J. 4 (2), 277). Each chimaeric DNA sequence also comprises the 35S3 promoter (Hull and Howell (1987) Virology 86, 482-493) fused in frame with the sfr gene encoding phosphinothricine resistance (EPA 87400544.0) and the 3' end signal of the T-DNA gene 7 (Velten and Schell (1985) NAR 13, 6987).

Example 5

Construction of plant transformation vectors containing the barstar gene under the control of the tapetum-specific promoters of Example 2

Suitable vectors, which carry both the barstar-encoding DNA (Hartley and Rogerson (1972), supra) under the control of the tapetum-specific PT72 promoter of this invention (Example 2) and the herbicide resistance gene, bar (EP 0,242,236), under the control of the 35S3 promoter (EP 0,359,617) and which can be used for the transformation of rice (in Example 7) and corn (in Example 8), are constructed in a procedure comprising four steps as outlined below. Plasmid pVE108, the sequence of which is shown in SEQ ID no. 9, is used.

Step 1.

A DNA fragment, carrying the 3' untranslated end of the nos gene of Agrobacterium T-DNA, is amplified from pVE108 by means of the polymerase chain reaction (PCR; Sambrook et al (1989) supra) using the following two oligonucleotides (CASOL3 and CASOL4) as primers :

CASOL3:

5'-TGG CCA TGG AGG GTA ACC TCC GAA GCA GAT CGT TCA-3'

CASOL4:

5'-CGA ATT CAT ATG CAC GTG TTC CCG ATC TAG TAA CAT-3'.

The resulting fragment is recovered, cleaved with EcoRI and NcoI, and ligated to the large fragment of plasmid

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pVE108 cleaved with the same enzymes, yielding plasmid pTSX11.

Step 2.

A fragment containing a tapetum-specific promoter PT72 and a barstar gene is constructed as follows:

- 1) a DNA fragment, carrying the barstar coding sequence, is amplified from pMT416 (Hartley (1988) J.Mol.Biol. 202, 913) by means of PCR using the following two oligonucleotides (CASOL13T72 and CASOL14) as primers :

CASOL13T72:

5'-CGG CAG AAG ACA CTC ACG GCG ATG AAA AAA GCA GTC
ATT AAC-3'

CASOL14:

5'-GGG GGT TAC CTT AAG AAA GTA TGA TGG TGA-3'; and

- 2) a DNA fragment, carrying the barstar coding sequence under the control of the PT72 promoter of Example 2, is amplified from pT72 (Example 2) by means of PCR using as primers: i) the gel-purified PCR product of step 1), ii) CASOL14, and iii) the following oligonucleotide (T72POL1):

5'-TGG CCA TGG AGC TAG CGG CCG CCA CAG AAC AGG ATA
GCA A-3'.

The final fragment contains not only the barstar coding sequence under the control of the PT72 promoter but also comprises: at its 5' end, a linker sequence containing restriction sites for MscI, NcoI, NheI and NotI; and at its 3' end, a linker sequence comprising a BstEII restriction site and a 3 nucleotide spacer (GGG).

Step 3.

The final fragment of Step 2 is recovered, cleaved with NcoI and BstEII, and ligated to the large fragment of

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plasmid pTSX11 (Step 1) cleaved with the same enzymes, yielding plasmid pTSX11-T72.

Step 4.

A fragment containing the 35S3 promoter is amplified from pDE9 (EP 0,359,617) by means of PCR using the following two oligonucleotides as primers :

5'-TGG CCA TGG TTA TAG AGA GAG AGA TAG ATT T-3'

5'-GAA GCT AGC AAT CCC ACC AAA ACC TGA ACC T-3'.

The resulting fragment is recovered, cleaved with NcoI and NheI, and ligated to the large fragment of pTSX11-T72 (Step 3) cleaved with the same enzymes, yielding the plasmid designated as "pJVR1-T72".

For constructions with the PE1 promoter instead of the PT72 promoter, the four step procedure, described above, is followed except that in step 2 the following two oligonucleotides (CASOL13E1 and E1POL1) are used instead of CASOL13T72 and T72POL1 respectively:

CASOL13E1:

5'-GAG ATC CAT CAA GCC GTC GCG ATG AAA AAA GCA GTC
ATT AAC-3'

E1POL1:

5'-TGG CCA TGG AGC TAG CGG CCG CAG ATC CTT CTG TGT
GAT TG-3'.

The plasmid obtained after step 3 is designated as "pTSX11-E1" while the plasmid obtained after Step 4 is designated as "pJVR1-E1".

For constructions with the PT42 promoter instead of the PT72 promoter, the four step procedure, described above, is used except that:

- 1) in step 2, the following two oligonucleotides (CASOL13T42 and T42POL1) are used instead of CASOL13T72 and T72POL1 respectively:

CASOL13T42:

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5'-CAA CTC CCC TCC TCC ACT AGA CCA CCA TGA AAA AAG
CAG TCA TTA AC-3'

T42POL1:

5'-GCT AGC GGC CGC ATG GCA GAG CAC GGC CAG-3';

- 2) the fragment obtained in step 2 is inserted in pTSX11 (Step 3) as follows: the fragment is made blunt end with Klenow and cleaved with BstEII and is then ligated to the large fragment of pTSX11 cleaved with NcoI (filled-in with Klenow) and BstEII. The resulting plasmid is designated as "pTSX11-T42"; and
- 3) the NotI-HindIII fragment of pJVR1-T72, carrying the bar gene under the control of the 35S3 promoter, is ligated to the large fragment of pTSX11-T42 cleaved with the same enzymes. The plasmid obtained is designated as "pJVR1-T42".

Alternative constructions are also made starting from plasmid pUCNew1 (Example 6). The barstar encoding DNA present on pUCNew1 is first removed by digestion with XhoI and religation, yielding plasmid pUCNew2. The EcoRI-HindIII fragments from pJVR1-T72, pJVR1-E1 and pJVR1-T42, each carrying the barstar-encoding DNA under the control of a rice anther-specific promoter and the bar gene under the control of the 35S3 promoter, are then inserted in the EcoRI and HindIII sites of pUCNew2, yielding pJVR3-T72, pJVR3-E1, pJVR3-T42 respectively.

Plasmids pJVR3-T72, pJVR3-E1, pJVR3-T42, pJVR1-T72, pJVR1-E1, pJVR1-T42 are used for the transformation of rice and corn as described in Examples 7 and 8, respectively.

T-DNA vectors for Agrobacterium-mediated plant transformations are prepared by cloning the appropriate EcoRI (filled-in with Klenow)- HindIII fragments of pJVR1-T72, pJVR1-E1, and pJVR1-T42 (containing the

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35S3-bar and rice anther-specific promoter-barnase chimaeric genes) between the HindIII and XbaI (filled-in with Klenow) sites of the known T-DNA vectors pGSC1700 or pGSC1701A. pGSC1700 has been deposited on March 21, 1988 at the Deutsche Sammlung für Mikroorganismen und Zellkulturen (DSM), Mascheroderweg 1B, D-330 Braunschweig, Germany under DSM accession number 4469, and pGSC1701A has been deposited on October 22, 1987 at the DSM under DSM accession number 4286. The T-DNA vectors are used for transformation of tobacco as described in Example 9.

Example 6

Construction of plant transformation vectors containing the barnase gene under the control of the tapetum-specific promoters of Example 2

The tapetum-specific PT72, PT42 and PTE1 promoters of Example 2 are also directly cloned in plant transformation vectors containing the barnase-encoding male-sterility DNA and barstar-encoding fertility-restorer DNA of Example 4. Plasmid pVE108, the sequence of which is shown in SEQ ID no. 9, is used. The plasmid contains a chimaeric gene comprising: the bar gene (EP 0,242,236) under the control of the 35S3 promoter (EP 0,359,617) and with the 3' regulatory sequence of the nopaline synthase gene; and the barnase gene under the control of the tapetum-specific promoter of the TA29 gene (EP 0,344,029) of Nicotiana tabacum and with the 3' regulatory sequence of the nopaline synthase gene. For constitutive expression of the bar gene, an equivalent 35S3 promoter also is used, which differs from the one described in EP 0,359,617 by a 550 bp EcoRI-StuI deletion.

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The large NcoI fragment of plasmid pVE108 (filled-in with the large fragment - Klenow - of DNA polymerase I of E. coli) is first ligated to the fragment of the 35S3 promoter as described in EP 0,359,617, amplified by means of the polymerase chain reaction (PCR) using the following two oligonucleotides as primers:

5'-ATT ATA GAG AGA GAG ATA GAT TT-3'

5'-GCA ATC CCA CCA AAA CCT GAA CCT-3'.

The plasmid, in which the NcoI site is reconstructed at the ATG translation initiation codon of the barnase gene, is designated "pVE108del". In this plasmid, the NcoI site at the ATG translation initiation codon of the bar gene is lost.

Then, pVE108del is digested with NcoI, filled in with Klenow, and ligated to one of the following DNA fragments:

1. a 1602 bp fragment obtained by PCR amplification from pGT72 using the following primers:

5'-ATT CCA CAG AAC AGG ATA GC-3'

5'-GCC GTG AGT GTC TTC TGC CG-3'.

The resulting plasmid, in which the promoter fragment from pGT72 is appropriately positioned with respect to the barnase coding sequence, is designated "pVE108-T72";

2. a 1532 bp fragment obtained by PCR amplification from pGT42 using the following primers:

5'-CCA TGG CAG AGC ACG GCC AG-3'

5'-GTG GTC TAG TGG AGG AGG GGA GTT G-3'.

The resulting plasmid, in which the promoter fragment from pGT42 is appropriately positioned with respect to the barnase coding sequence, is designated "pVE108-T42"; and

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3. a 1690 bp fragment obtained by PCR amplification from pGE1 using the following primers:

5'-CCT CAG ATC CTT CTG TGT GA-3'

5'-GCG ACG GCT TGA TGG ATC TCT TGC-3'.

The resulting plasmid, in which the promoter fragment from pGT72 is appropriately positioned with respect to the barnase coding sequence, is designated "pVE108-E1".

Alternatively, plasmids pVE108-T72, pVE108-T42 and pVE108-E1 are obtained directly by cloning, in pVE108del, their corresponding promoter fragments obtained by direct PCR amplification from rice genomic DNA using the above-mentioned primers of this Example.

Alternatively, suitable vectors, which carry both the barnase-encoding DNA under the control of the tapetum-specific PT72, PTE1 or PT42 promoter of this invention (Example 2) and the bar gene under the control of the 35S3 promoter and which can be used for transformation of rice (Example 7) and corn (Example 8), are constructed by the four step procedure of Example 5. However, the oligonucleotides used in Step 2 are complementary to the barnase gene in pMT416 instead of to the barstar gene. In this regard, CASOL13T72 is replaced by CASOL15T72, CASOL13T42 is replaced by CASOL15T42, CASOL13E1 is replaced by CASOL15E1, and CASOL14 is replaced by CASOL16. These replacement oligonucleotides are as follows:

CASOL15T72:

5'-CGG CAG AAG ACA CTC ACG GCG ATG GTA CCG GTT ATC
AAC ACG-3'

CASOL15T42:

5'-CAA CTC CCC TCC TCC ACT AGA CCA CCA TGG TAC CGG
TTA TCA ACA CG-3'

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CASOL15E1:

5'-GAG ATC CAT CAA GCC GTC GCG ATG GTA CCG GTT ATC
AAC ACG-3'

CASOL16:

5'-GGG GGT TAC CTT ATC TGA TTT TTG TAA AGG TCT G-3'.

The final constructions obtained after step 4 are designated as "pJVR2-T72", "pJVR2-E1" and "pJVR2-T42" respectively.

All vector constructions, containing the barnase-encoding DNA are made in plasmid pMc5-BS in *E. coli* WK6. Plasmid pMc5-BS contains the barstar-encoding DNA gene under the control of the tac promoter (De Boer et al (1983) PNAS 80, 21) and is constructed by cloning the EcoRI-HindIII fragment of pMT416 (Hartley (1988) J.Mol.Biol. 202, 913) into pMc5-8 (deposited on May 3, 1988 at the DSM under DSM accession number 4566). The sequence starting with the PhoA signal sequence and ending with the last nucleotide before the translation initiation codon of the barstar-coding region is deleted by looping-out mutagenesis according to the general procedures described by Sollazi et al (1985) Gene 37, 199. The availability of an ampicillin resistance gene on the pUC18-derived plasmids carrying the chimaeric barnase-coding sequence and the chloramphenicol resistance gene on pMc5-BS permits the strain to be kept stable on plates provided with the two antibiotics or to select for any one plasmid. While normally repressed, gene expression from this promoter can be induced by the addition of a commonly used inducer of the lac operon, IPTG (isopropyl- β -d-thiogalactopyranoside).

Alternatively the barstar-encoding DNA under the control of the tac promoter is inserted in the same plasmid as that carrying the barnase-encoding DNA under

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the control of a rice anther-specific promoter of this invention as follows.

In a first step, a new plasmid is constructed by ligation of the three following DNA fragments:

- A DNA fragment, comprising the β -lactamase gene from pUC19 (Yanisch-Perron et al (1985) Gene 33, 103), is amplified from pUC19 by means of PCR using the following two oligonucleotides (CASOL9 and CASOL11):

CASOL 9:

5'-GGA ATT CAA GCT TGA CGT CAG GTG GCA CTT-3'

CASOL11:

5'-TGG GGA GTA AGC TCG AGC CAA AAA GGA TCT TCA
CCT AG-3'.

- Another DNA fragment, comprising the origin of replication of pUC19, is amplified from pUC19 by means of PCR using the following two oligonucleotides (CASOL10 and CASOL12):

CASOL10:

5'-GGA ATT CTG ATC AGG CCA ACG CGC GGG GAG A-3'

CASOL12:

5'-TCT TAA TAC GAT CAA TGG CTC GAG TCT CAT GAC CAA
AAT CCC TTA-3'.

- Yet another DNA fragment, comprising the barstar-encoding DNA under the control of the tac promoter, is amplified from pMc5-BS by means of PCR using the following two oligonucleotides (CASOL17 and CASOL18):

CASOL17:

5'-CGG CTC GAG CTT ACT CCC CAT-3'

CASOL18:

5'-CCG CTC GAG CCA TTG ATC GTA TTA AGA-3'.

These three DNA fragments are then cleaved with XhoI and EcoRI and ligated to one another. The resulting plasmid, which resembles pUC19 but which has a deleted

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lac region, an altered polylinker, and the barstar-encoding DNA under the control of the tac promoter inserted between the β -lactamase gene and the origin of replication of PUC19 (with the barstar-encoding DNA in the same orientation as the β -lactamase gene), is designated as "pUCNew1". The EcoRI-HindIII fragments from pJVR2-T72, pJVR2-E1 and pJVR2-T42, each carrying the barnase-encoding DNA under the control of one of the rice anther-specific promoters of this invention and the bar gene under the control of the 35S3 promoter, are then each inserted in the EcoRI and HindIII sites of pUCNew1, yielding pJVR4-T72, pJVR4-E1 and pJVR4-T42 respectively.

Plasmids pVE108-T72, pVE108-T42, pVE108-E1, pJVR2-T72, pJVR2-T42, pJVR2-E1, pJVR4-T72, pJVR4-T42 and pJVR4-E1 are each used for transformation of rice and corn as described in Examples 7 and 8, respectively.

T-DNA vectors for Agrobacterium-mediated plant transformations are prepared by cloning the appropriate EcoRI (filled-in with Klenow) - XbaI fragments of pVE108-T72, pVE108-T42, pVE108-E1, pJVR2-T72, pJVR2-T42, pJVR2-E1, pJVR4-T72, pJVR4-T42 and pJVR4-E1 (containing the 35S3-bar and rice anther-specific promoter-barnase chimaeric genes) between the HindIII (filled-in with Klenow) and XbaI sites of the known T-DNA vectors, pGSC1700 (DSM 4469) or pGSC1701A (DSM 4286). The T-DNA vectors are used for transformation of tobacco as described in Example 9.

Example 7

Transformation of rice with the plant transformation vectors from Examples 5 and 6

Using the procedures described by Datta et al (1990) supra, protoplasts of the rice line, *Oryza sativa* var. Chinsurah boro II, are transformed with the plant

transformation vectors described in Examples 5 and 6, and transformed plants are regenerated from the protoplasts.

Alternatively, immature embryos from rice varieties Gulfmont, Lemont, IR26, IR 36, IR54, and IR72 are bombarded with gold particles, carrying appropriate plasmid DNA of Examples 5 and 6, and transformed plants are regenerated from the embryos by the procedures described by Christou et al (1991) Bio/Technology 9, 957. In this regard, transformations with male-sterility DNAs and male fertility-restorer DNAs are carried out using pJVR2-T72, pJVR2-E1, pJVR2-T42, pVE108-T72, pVE108-E1, pVE108-T42, pJVR1-T72, pJVR1-E1, and pJVR1-T42 (Examples 5 and 6), either directly or following suitable linearization after the PT72- and PT42-containing plasmids are digested with EcoRI and HindIII and the PE1-containing plasmids are digested with EcoRI and PstI. These transformations are also carried out with foreign DNA sequences of this invention containing only a male-sterility DNA or a fertility-restorer DNA and a selectable marker DNA, using pJVR4-T72, pJVR4-E1, pJVR4-T42, pJVR3-T72, pJVR3-E1, and pJVR3-T42 (Examples 5 and 6), after being digested with EcoRI and XhoI and then size fractionated by agarose gel electrophoresis or by sucrose gradient centrifugation, so that each foreign DNA sequence can be recovered, digested with XhoI, after which: the fragments are filled-in in a reaction with T4 DNA polymerase, dATP, dCTP, dGTP and biotin-dUTP; and after heat inactivation of the enzymes, the DNA is further digested with EcoRI, and the biotinylated XhoI ends are removed on a streptavidin agarose column (Sigma) or on streptavidin magnetic beads (Promega).

Each transformed plant, containing the tapetum-specific PT72, PT42 or PE1 promoter of Example 2

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controlling either a male-sterility DNA or a fertility-restorer DNA, is normal except for its flowers. In this regard, each plant containing a male-sterility DNA under the control of a tapetum-specific promoter expresses such DNA at least predominantly in its tapetum cells and produces no normal pollen, and each plant containing a fertility-restorer DNA under the control of a tapetum-specific promoter expresses such DNA at least predominantly in its tapetum cells but produces normal pollen.

Example 8

Transformation of corn with the plant transformation vectors from Examples 5 and 6

Using the procedures described by Fromm et al (1990) supra, embryogenic suspension cultures of a B73 X A188 corn line are transformed with the plant transformation vectors described in Examples 5 and 6, and transformed plants are regenerated from the embryogenic suspension cultures. Alternatively, immature embryos from the B73 X A188 corn line are transformed with gold particles carrying the plasmid DNA of Examples 5 and 6, and transformed plants are regenerated from the embryos as described in Example 7. Each transformed plant, containing the tapetum-specific PT72, PT42 or PE1 promoter of Example 2 controlling either a male-sterility DNA or a fertility-restorer DNA, is normal except for its flowers. In this regard, each plant containing a male-sterility DNA under the control of a tapetum-specific promoter expresses such DNA at least predominantly in its tapetum cells and produces no normal pollen, and each plant containing a fertility-restorer DNA under the control of a tapetum-specific promoter expresses such DNA at least predominantly in its tapetum cells but produces normal pollen.

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Example 9Transformation of tobacco with the plant transformation vectors from Examples 4, 5 and 6

Using the procedures described in EPA 89401194.9 and 90402281.1, tobacco plants are transformed by Agrobacterium-mediated transfer with the plant transformation vectors containing the foreign chimaeric DNA sequences from Examples 4, 5 and 6. The transformed tobacco plants, each containing one of the anther-specific promoters of Example 2 controlling either a male-sterility DNA or a fertility-restorer DNA, are normal except for their flowers. In this regard, each plant containing a male-sterility DNA under the control of an anther-specific promoter expresses such DNA at least predominantly in its anthers and produces no normal pollen, and each plant containing a male fertility-restorer DNA under the control of an anther-specific promoter expresses such DNA at least predominantly in its anthers but produces normal pollen.

Needless to say, the use of the anther-specific rice promoters of this invention is not limited to the transformation of any specific plant(s). The rice promoters can be useful in any crop where they are capable of controlling gene expression, and preferably where such expression is to occur at least predominantly, preferably specifically, in stamen cells of the crop. Also, the use of these promoters is not limited to the control of male-sterility DNAs or fertility-restorer DNAs but can be used to control the expression of any gene selectively in stamen cells.

Furthermore, this invention is not limited to the specific stamen-specific, preferably anther-specific, particularly tapetum-specific, promoters described in the

foregoing Examples. Rather, this invention encompasses promoters equivalent to those of Example 2 which can be used to control the expression of a structural gene, such as a male-sterility DNA or a fertility-restorer DNA, selectively in stamen cells, preferably anther cells, particularly tapetum cells, of a plant. Indeed, it is believed that the DNA sequence of each of the promoters of Example 2 can be modified by replacing some of its nucleotides with other nucleotides, provided that such modifications do not alter substantially the ability of polymerase complexes, including transcription activators, of stamen cells, particularly anther cells, to recognize the promoter, as modified.

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TABLE 1 : PROFILES OF SELECTED DIFFERENTIAL CLONES**TABLE 1A**

name	cDNA size	mRNA size	copy number	dot blot assay for expression in RNA sample		
				anther	spikelet	
					1.5-3 mm	4-6 mm
E1	530	800	1	8	7	7
T72	400	800	1	9	7	9
T157	600	1900	1	7	0	7
T149	500	2600	1	7	2	8
T42	270	800	1	8	7	6
T146	1200		1	4	1	5
T139	200	1200	1	8	6	7
T155	250	900	1	7	4	5
T34	650	800	1	9	8	7
T23	1000	1300	1	8	4	9
T118	700	1100	1	5	7	5
E2	700	800	1	6	6	5

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TABLE 1 B

name	cDNA size	mRNA size	copy number	dot blot assay for expression in RNA sample					
				leaf	root	basis of spikelet			
						1	2a	2b	2c
E1	530	800	1	0	0	0	1	1	1
T72	400	800	1	0	0	0	2	1	1
T157	600	1900	1	0	1	0	1	1	1
T149	500	2600	1	0	1	0	1	1	1
T42	270	800	1	0	1	0	2	1	1
T146	1200		1	1	1	1	1	1	1
T139	200	1200	1	1	0	0	2	2	1
T155	250	900	1	1	1	1	1	1	1
T34	650	800	1	2	2	1	2	2	2
T23	1000	1300	1	2	1	2	2	2	2
T118	700	1100	1	3	2	2	2	2	2
E2	700	800	1	3	3	2	2	2	2

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TABLE 1 C

name	cDNA size	mRNA size	copy number	dot blot assay for expression in RNA sample		
				dry seed	callus	axis
E1	530	800	1	0	0	0
T72	400	800	1	0	0	0
T157	600	1900	1	0	0	1
T149	500	2600	1	0	0	1
T42	270	800	1	0	0	0
T146	1200		1	0	1	1
T139	200	1200	1	1	1	0
T155	250	900	1	0	1	1
T34	650	800	1	0	2	2
T23	1000	1300	1	0	3	3
T118	700	1100	1	0	3	3
E2	700	800	1	0	4	3

legend : - basis of spikelet subdivision:

1 : "white" spikelets of 6-6.5 mm

2a, 2b, 2c : immature spikelets of 3-5 mm; the three categories correspond to different samples of mRNA from different batches of the same type of tissue

(preparations of basis of spikelets may have been contaminated with remnants of anthers)

- 1 to 9 : corresponds to expression level ; 0 corresponds to a hybridization level not higher than the background (hybridization obtained with pGEM2 without insert).

- empty boxes : not determined

- mRNA size : has been determined by Northern blot

- copy number : corresponds to the number of hybridizing bands detected with the cDNA inserts as a probe in Southern blots of Akihikari leaf genomic DNA digested with a majority of restriction enzymes tested (AvaI, BamHI, BglII, EcoRI, HindIII, KpnI, MspI, RsaI, and SacI).

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SEQUENCE LISTING

1. General Information

- i) APPLICANT : PLANT GENETIC SYSTEMS N.V.
- ii) TITLE OF INVENTION : Stamen-specific promoters from rice
- iii) NUMBER OF SEQUENCES : 9
 - SEQ. ID. NO 1 : cDNA T72
 - SEQ. ID. NO 2 : cDNA T23
 - SEQ. ID. NO 3 : cDNA T42
 - SEQ. ID. NO 4 : cDNA T155
 - SEQ. ID. NO 5 : cDNA E1
 - SEQ. ID. NO 6 : genomic DNA hybridizing to cDNA T72
 - SEQ. ID. NO 7 : genomic DNA hybridizing to cDNA T42
 - SEQ. ID. NO 8 : genomic DNA hybridizing to cDNA E1
 - SEQ. ID. NO 9 : plasmid pVE108
- iv) CORRESPONDENCE ADDRESS :
 - A. ADDRESSEE : Plant Genetic Systems N.V.
 - B. STREET : Plateaustraat 22,
 - C. POSTAL CODE AND CITY : 9000 Ghent,
 - D. COUNTRY : Belgium
- v) COMPUTER READABLE FORM :
 - A. MEDIUM TYPE 5.25 inch, double sided, high density 1.2 Mb floppy disk
 - B. COMPUTER : IBM PC/AT
 - C. OPERATING SYSTEM : DOS version 3.3
 - D. SOFTWARE : WordPerfect 5.1
- vi) CURRENT APPLICATION DATA : Not Available
- (vii) PRIOR APPLICATION DATA :
 - EPA 91400318.1, filed February 8, 1991
 - EPA 91402590.3, filed September 27, 1991
 - EPA 91403352.7, filed December 10, 1991

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2. Sequence Description : SEQ ID NO. 1

SEQUENCE TYPE: nucleotide sequence

SEQUENCE LENGTH: 446 bp

STRANDEDNESS: double stranded

TOPOLOGY: linear

MOLECULAR TYPE: cDNA to mRNA

ORIGINAL SOURCE:

ORGANISM: rice

ORGAN : anther

FEATURES:

- Nucleotide (nt) 1 to nt 21 : cloning adaptor sequence
- nt 22 to nt 429 : cDNA T72
- nt 430 to nt 446 : cloning adaptor sequence

Open reading frames starting from start of cDNA sequence

- from nt 22 to nt 144
- from nt 23 to nt 334
- from nt 24 to nt 119

PROPERTIES: cDNA designated as T72

CCGGGGATCC	GGGTACCATG	GCGGCGCTGG	GCGCCGTGTC	GCACGACTGC	50
GCCTGCGGCA	CGCTCGACAT	CATCAACAGC	CTCCCCGCCA	AGTGCGGCCT	100
CCCGCGCGTC	ACCTGCCAGT	GATGGAGATG	GTGTGCCAAG	GTAATTGCGT	150
TTGCTCGTGC	GAGGATGAGA	AGAGAAGATT	GAATAAGATG	TTTGATGGCA	200
ACAAGTCATC	AGGCGATCCG	ATCCCTGCAG	CTATGAATGG	GAGTATACGT	250
AGTAGTGGTC	TCGTTAGCAT	CTGTGTGTCG	CATATGCACG	CCGTGCGTGC	300
CGTGTCTGTC	CTGCTTGCTC	TGCTGATCGT	TCAATGAACG	ACAAATTAAT	350
CTAACTCTGG	AGTGACAAGT	CGTTCGAGAT	ATACTAATAC	TACCATGTGC	400
AGGGTCTTTC	AACCAAAAAA	AAAAAAAAC	CATGGTACCC	GGATCC	446

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3. Sequence Description : SEQ ID NO. 2

SEQUENCE TYPE: nucleotide sequence
SEQUENCE LENGTH: 347 bp

STRANDEDNESS: double stranded
TOPOLOGY: linear
MOLECULAR TYPE: cDNA to mRNA

ORIGINAL SOURCE:
ORGANISM: rice
ORGAN : anther

FEATURES: - Nucleotide (nt) 1 to nt 332 : cDNA T23
 - nt 333 to nt 347 : cloning adaptor sequence

PROPERTIES: part of cDNA designated as T23

AGATGGACAC	CGCCAGATCA	GGGCTCTCGG	CTTCCCGCCA	TTCCTCTCCG	50
TTCAGCAGAT	GTTCGACGAC	TCGATCAAGA	GCGTCCAGGA	CAAGGGCCTC	100
CTTCCTCCTC	ATGCTTGATT	CATATGATCC	ACACAATTAA	GCTGCTTGAT	150
TAATTATAAC	TAATCAAATA	TTGTTAAGGA	TCGGAATCAC	GTAGTACCGA	200
TCATATATGT	G TTCATCTCG	AAATTA ACTG	TAAGTGTGAG	ATCGAGAATA	250
CACTAATACA	GTGCTAATAT	ATACCGAAAT	GTTTGTA AAA	AAAAAAAAAAA	300
AAAAAAAAAAA	AAAAAAAAAAA	AAAAAAAAAAA	AACCATGGTA	CGGATCC	347

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SEQUENCE TYPE: nucleotide sequence
SEQUENCE LENGTH: 294 bp

ORIGINAL SOURCE:

ORGANISM: rice
ORGAN : anther

FEATURES:

- Nucleotide (nt) 1 to nt 16 : cloning adaptor sequence
- nt 17 to nt 284 : cDNA T42
- nt 285 to nt 294 : cloning adaptor sequence

PROPERTIES: cDNA designated as T42

GAATTCGGTA	CCATGGCGCC	GCCTGCGGCC	TCTCCATCAG	CTTCACCATC	50
GCCCCCAACA	TGGA CTGCAA	CCAGGTTACA	GAGGAACTGA	GAATCTGAGA	100
GCGTGAGGAA	TCGAGTTCAT	GTTGCATTTA	TCATCAATCA	TCATCGACTA	150
GATCAATAAA	TCGAGCAAAG	CTTTGATAAA	GAGCGAGCCG	CCTTAATTAA	200
TTTACAATAA	TCTTGGATGT	CATCCTGCAT	GYGTGTATGA	TCACACGGTT	250
GTTTAATTAG	GCACTTTAAT	TTTGCAAAAA	AAAACCATGG	TACC	294

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5. Sequence Description : SEQ ID NO. 4

SEQUENCE TYPE: nucleotide sequence
SEQUENCE LENGTH: 268 bp

STRANDEDNESS: double stranded
TOPOLOGY: linear
MOLECULAR TYPE: cDNA to mRNA

ORIGINAL SOURCE:
ORGANISM: rice
ORGAN : anther

FEATURES: - Nucleotide (nt) 1 to nt 7 : cloning adaptor
 sequence
 - nt 8 to nt 253 : cDNA T155
 - nt 254 to nt 268 : cloning adaptor sequence

PROPERTIES: cDNA designated as T155

ACCATGGGTT	GTGTTAGCGC	GCGGCAAAAG	TTACCGTCGT	GATCATTTCT	50
GGGCTACTTC	CAGCAGGAGA	TCGGCCTAGC	TGGTGTCTTA	ATTAATTATA	100
TGTGATGTGC	TGTTCCGTTT	TCTGTGATGT	GTGTCATCCG	TTTCATACTC	150
CGTATCGATC	ATCATTATGT	GTTTCCGGTA	GGAATTTGCG	CTCGATATAT	200
GGTGATCCAA	AATTTATGAA	TCAATTCTTC	GTGATTCACT	CTGTAAAAAA	250
AAACCATGGT	ACCCCGGG				268

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6. Sequence Description : SEQ ID NO. 5

SEQUENCE TYPE: nucleotide sequence
SEQUENCE LENGTH: 617 bp

STRANDEDNESS: double stranded
TOPOLOGY: linear
MOLECULAR TYPE: cDNA to mRNA

ORIGINAL SOURCE:

ORGANISM: rice
ORGAN : anther

FEATURES: - Nucleotide (nt) 1 to nt 58: cloning adaptor
 sequence
 - nt 59 to nt 593 : cDNA E1
 - nt 594 to nt 617 : cloning adaptor sequence

PROPERTIES: cDNA designated as E1

ACAGGTCGAC	TCTAGAGGAT	CCCCGGGCGA	GCTCGAATTC	GAGATCCGGG	50
TACCATGGGC	AAGAGATCCA	TCAAGCCGTC	GCGATGACGA	CGAGGCCTTC	100
TGTTTTTTCC	ACCGTTGTCG	CGGCGATCGC	CATCGCCGCG	CTGCTGAGCA	150
GCCTCCTCCT	CCTGCAGGCT	ACCCCGGCCG	CGGCCAGCGC	GAGGGCCTCG	200
AAGAAGGCTT	CGTGCGACCT	GATGCAGCTG	AGCCCGTGCG	TCAGCGCGTT	250
CTCCGGTGTG	GGGCAGGGCT	CGCCATCGTC	CGCGTGCTGC	TCCAAGCTCA	300
AGGCGCAGGG	CTCCAGCTGC	CTGTGCCTCT	ACAAGGACGA	CCCCAAAGTG	350
AAGCGCATTG	TCAGCTCCAA	TCGCACCAAG	AGGGTCTTCA	CCGCGTGCAA	400
GGTGCCCGCG	CCGAAGTGCT	AAGCCTTTGC	ATTGACCAT	TGTTCAAGTGA	450
GGCAGAAAAC	CTGTCACCGC	TCGCAGTACT	TCTCTCGAGA	AAATTAGCAG	500
TAATAAACTC	AGTTGAGTGC	ATAACAATCT	TGGCATGTAC	TGTGCATACA	550
GTGTACTTCA	AGCTACCCAA	ACTCCGAAGC	AGTTCTGTCT	TCCCCATGGT	600
ACCCGGATCT	CGAATTC				617

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7. Sequence Description : SEQ ID NO. 6

SEQUENCE TYPE: nucleotide sequence

SEQUENCE LENGTH: 3627 bp

STRANDEDNESS: double stranded

TOPOLOGY: linear

MOLECULAR TYPE: genomic DNA

ORIGINAL SOURCE:

ORGANISM: *Oryza sativa*

FEATURES: - nt 1 to nt 2845 : sequence comprising anther-specific PT72 promoter
 - nt 2733 to nt 2739 : TATA box
 - nt 2765 : transcription initiation determined by primer extension
 - nt 2846 : ATG start of translation of T72 gene ; the sequence downstream from this position overlaps with the sequence of the cDNA of SEQ ID No. 1

PROPERTIES: genomic DNA from *Oryza sativa* designated as GT72

GACAATACAT	CAAGTAAATC	AAACATTACA	AATCAGAACC	TGTCTAAGAA	50
TCCATCTTAA	TTCAGAAAAA	AACTCAGATT	AGATGTTTCAT	GCTTCCACCA	100
GAAGCAGGAA	TGTGCAACCT	ACACTTCCTG	TAATTTCCAT	ACTACAATGT	150
CCCCACTGAC	CACTGTGCCT	GATGCTCTAT	TAGAATACCA	CATCCTCCAT	200
GGCTCCATGT	AAATGCATAT	AAATTTGACT	CTTTAAATTA	GTAACCTACAA	250
TTTAAAATTT	ATCGAACATT	GTTCAAATTT	ATAAACAGTT	TCCCCAAATT	300
TAGATGCTCC	CAAATGTACA	CAGCTACTAG	TAAAGCACCA	TCCAGTTTCA	350
CCTGAACAGG	ACTGACATAA	ATGTGTGAAA	AGGGGACGTC	ATTCCCCCAA	400
ATACAACTGA	ACAATCCTCC	ATCAGAACAT	TCATTTGATT	GACATTACTC	450
GGAGAGATAC	AGCTCGCAGG	CACACGAGAT	TCTTCTGCCT	TTCCAATTGC	500
CACGAACCCA	CATGTCACAC	GACCAACCAA	AAAGAGAGAA	TTTTTCTTTG	550
CACAAACAAA	AAGTGAGATT	TTTTTTTTCGC	CACAAAGGTG	CGAACTTTCT	600
TCTCTCTCCC	ACTTTCCAAT	CAAGAAACGA	AGCACTCAA	CCAAGAACAA	650
ACCAAGGAAG	GAGAGATCGC	TCCCTCTCCC	AGAGCAAACG	AAAGGAGAGA	700
ACTCAGATGG	ATGCGAACTA	CTACCTTGCC	TCTTTCCCCG	GAGAAGCAGC	750
GAAGGAGAAG	AGCGCGATGC	CGCCGCCGCC	GCCGCCTCCG	GCAACCTCCG	800
GCTCCGGCGA	GTCCGCCTCC	TCCTCCTCTC	TCACCTCTCT	CTTCCCAACC	850
GTGTGGTGTT	CGAGAAGCTT	TTATGCGAGC	GACGTGCAGT	GGAAGCGGTT	900
GCTCCCAAGT	CAAACCTGATG	GAGACCACCT	ACTATCTTCC	TCTTGTTTTT	950
TTCTGCTTTT	CTTTTCTTTA	TCTTTTTTCT	TTCATTTTAT	TTTGAGCGAT	1000
GAACTTGAGA	ACAGTTTGGT	TGTGGGTAA	ATTAAACGGT	GCAGAATTGC	1050
AAAGCTACGT	CCTTTTTCGTC	TGATTAAGGT	GGTATCAGAA	TCCTAATCTG	1100
TTAGCTCAGC	ATTGTTTTTT	GTGTGTTTAA	TTGGCCATGA	CATCAGATGG	1150
TTCAGACCGG	TGGCAGGTCT	TCATCGGAGA	GGAGAATGAG	AGCAATGCAA	1200
GTTGCAAACA	ACAAACAGGT	CCTTCCAAAC	GGGTGTTT	CATTCCACAG	1250
AACAGGATAG	CAACCAGAGC	ACAAACCGTT	CAACAATATA	TATATATATA	1300
TATATATATA	TATATATATA	TATATATATA	TATATATATG	ATTTAAAATT	1350
ATATTACTAT	TTTTAGGATA	CGGAACTCTT	AACACATGAA	AATCTAAACA	1400
TTTTCAACCA	ATCAGAATA	CTAGAAAGAT	AATCTAACTA	CTTCAAAATT	1450

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TAAAATTTGA	CAAATAAAAT	AACTAGTTTT	TTCTAAAGCT	ATCTTCACTG	1500
GACAACTTAT	GAATATTTAT	ATTTATGAAG	CGAGTACTCT	CCTAGTACAT	1550
ATTACATATA	TATTCTTCTT	CTCATGAAAA	ATTAACCTCT	CGCTATAAAAT	1600
CCGAACATAT	ATTATGCGTA	GCAAGTTGTT	TTTTTTAAACG	GGTGGAGTAA	1650
TATTAGAGTA	TTTAAATTCC	TTCAAATTGC	CATCCCTCTG	GGACTTTGCT	1700
GCTGTTGTTC	TTCCACGGTT	GCTGTCAGTG	TCACCCAGAT	TTGCATCCTT	1750
TCCAGCTCGT	AGCTACTGTT	CTGCATGTAT	TGGACTTGGA	TTAAGATCAA	1800
ATGCAGTTGC	TATTGTAAC	GCACAATAGC	AACTGCACAC	AATCATGTCC	1850
ATTCGTTTTTC	AGATCCAACG	GCTCTAGATG	ACTGCTACAG	TACATGCATA	1900
ATAGTACATC	TCTGCTACAG	TGTTTTTTGCT	GCAGTACCAC	TTCATATCCT	1950
GGCCTTCCGT	TCTAGATCAT	GTGATGTACA	TGTTTTTTTG	AAACAACCCG	2000
CACAAGACAT	TGATAGAGTA	GGAAATGTGA	TGTACATGTT	AACGGCTTAA	2050
GTTACAGTTA	CAATAACAAC	TGCACAGGAT	CTTGATCCAT	TGGACTTGTA	2100
TAATATCTCA	TCTCGTCGTT	CCATTATCGT	GGTAACAGTT	GGCAACTTGG	2150
CATCCAGTGC	TGGAAACTAT	GCCGTGTGTA	CATCAGGATC	GTCCTTTTTG	2200
TTCAAGTTCCA	AGATAGAACA	AGTCCAAAAG	ATGGCCGCTAG	TTTTTTTTAGT	2250
CACAGTGGAA	GCTGACATAG	CCGTGGAATA	AGTTCTGCAC	AAAAGTTGCC	2300
ATTCGAGATC	AACTACTGGT	AGTAGTAGTC	ATCTTCTACC	ACTGCGAATA	2350
TTCGAAGGGA	CACAAAAAGA	TCAACGAGTA	AATTAGTTCA	CCGGAAGACG	2400
ACACATTATC	ACCACAAAAA	GACTAAAAAC	AAAAAGAAAT	TGCCAGGCCA	2450
AAAAAGGCAA	AAAAGAAAAA	AAAAGATGGC	ACGAGGCCCA	GGGCTACGGC	2500
CCATCTTGTC	GCCGGCCCAA	CCGCGCGCGC	GAAACGCTCT	CGTCGGCTCT	2550
CGGCTCGCCG	CGACGCGATG	GAGAGTTCCG	GCCGCGGCGC	GCGCGCGCGT	2600
TCGGTGGCTC	ACACGCTTGC	GCCCTCGTCC	TCCCGGCCGG	CGCGGGCGCC	2650
GACCGCGCGT	CCGCCGCATG	CGCGCGGCGT	AGGTGAGCAA	CGCGGGCCTC	2700
GCCGCGCGCG	CTCCCTCCT	TCGATCCCCT	CCTATAAATC	GAGCTCGCGT	2750
CGCGTATCGC	CACCACCACC	ACGACACACA	CGCACGCACC	GTGCAGGCAT	2800
CGACGACGAG	CGAGAGCCCC	TCGGCGGCAG	AAGACACTCA	CGGCGATGGC	2850
GGTGACGAGG	ACGGCGCTGC	TGGTGGTGTT	GGTAGCGGGG	GCGATGACGA	2900
TGACGATGCG	CGGGGCGGAG	GCGCAGCAGC	CGAGCTGCGC	GGCGCAGCTC	2950
ACGCAGCTGG	CGCCGTGCGC	GCGAGTCGGC	GTGGCGCCGG	CGCCGGGGCA	3000
GCCGCTGCCG	GCGCCCCCGG	CGGAGTGCTG	CTCGGCGCTG	GGCGCCGTGT	3050
CGCACGACTG	CGCCTGCGGC	ACGCTCGACA	TCATCAACAG	CCTCCCCGCC	3100
AAGTGCGGCC	TCCCGCGCGT	CACCTGCCGT	AAGAAAACGA	ATAAAATCGA	3150
TTTGCTATCT	ATCGATGATT	GTGTTTTTGT	AGACTAAACT	AAACCCCTAT	3200
TAATAATCAA	CTAACCGATG	AACTGATCGT	TGCAGAGTGA	TGGAGATGGT	3250
GTGCCAAGGT	AATTGCGTTT	GCTCGTGCGA	GGATGAGAAG	AGAAGATTGA	3300
ATAAGATGTT	TGATGGCAAC	AAGTCATCAG	GCGATCCGAT	CCCTGCAGCT	3350
ATGAATGGGA	GTATACGTAG	TAGTGGTCTC	GTTAGCATCT	GTGTGTGCGA	3400
TATGCACGCC	GTGCGTGCCG	TGTCTGTCTT	GCTTGCTCTG	CTGATCGTTC	3450
AATGAACGAC	AAATTAATCT	AACTCTGGAG	TGACAAGTCG	TTGAGATAT	3500
ACTAATACTA	CCATGTGCAG	GGTCTTTCAA	CCAAGGTTCA	TGTTTTCCAC	3550
GAAAGCCGAT	TGAAACGAAA	CCGCGAAATT	TTGATGCGAG	ATGAAAGCAG	3600
ATTCCGAGTG	AAATTTTAAA	TGGTTTTT			3627

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8. Sequence Description : SEQ ID NO. 7

SEQUENCE TYPE: nucleotide sequence

SEQUENCE LENGTH: 2370 bp

STRANDEDNESS: double stranded

TOPOLOGY: linear

MOLECULAR TYPE: genomic DNA

ORIGINAL SOURCE:

ORGANISM: *Oryza sativa*

FEATURES: - nt 1 to nt 1808 : sequence comprising anther-specific PT42 promoter
 - nt 1748 to nt 1755 : TATA box
 - nt 1780 : transcription initiation site determined by primer extension
 - nt 1809 : ATG start of translation of T42 gene ; the sequence downstream from this position overlaps with the sequence of the cDNA of SEQ ID No. 3

PROPERTIES: genomic DNA from *Oryza sativa* designated as GT42

GGCCATCACT	GTCGGGTGCT	GCGCCATGGA	CATCACCGTC	TCCTTCCTGC	50
GCCGCCGTCG	CCGGTGAGCT	CCAAGGCCGA	AGCCTTCTTC	CCCTCACGCC	100
ACTACCTCTC	TCTTCCCCAA	TTCCGGCCAA	CGCCGTCCGT	TGCCACAGCG	150
CCACCTCCAC	GCCATCCCAG	AGCCCCGTGC	CGTGCCACCG	GGTTCGCCTC	200
CATCTCCTCT	TGCCAACGCC	GACGCTCGTC	GCGGCAGCCA	TGCGCTGTCA	250
CCGATGAACA	CCGCCGCGCC	ACAGCCATGG	CAGAGCACGG	CCAGGGAGCC	300
ATGGCTGCTC	TGCCTCCTCC	TCCTTCTCTC	ACATCTGGTT	GCAGCCGGAC	350
CTAGTCGGCT	TATACAAATG	GCCCATGGGC	AAAATTGTCT	TTTATGAAAG	400
TTTCTCTCAC	CGTTTCAGTC	GGAAATAATA	AAATAATGGG	AGGATTGTCC	450
GCCAGCAAAT	TACCATATTT	TTTCGGTGTC	CAAGAGCAAA	TACACGATCT	500
TCGGGTGTTT	CACAGCAAAG	ACCACAATTT	CTAAGTGTCC	TGTAACAAAT	550
TTTGCCAATA	AAAATTTAAA	ACCAAAGGAG	AAGACTGTAC	ATGAAGAAAA	600
ACAAAGAGAA	TGAAATTACA	TAAGCTCAGG	GGTTATAAAG	TTGATTTATT	650
TTTAGGATGA	AGGAAGTGTG	TGAAAACAAT	GGCCAATTGG	GTGTCGGAAA	700
ATATAACGTG	CTTGCTAAAA	TGTCGTCCCC	ATATCCTGTA	GCTGATTATA	750
GATAGACCCT	GATGGTCAAG	ATGCCCTGTA	CTGGATCGTG	TTTCCATGCT	800
TCATCTCCGC	TTCTCTCAAG	TACTCCCCGA	ACTCACATAT	CTGGTGGGCT	850
GGATCCACAG	TAAGAAACAG	TCAAACAACA	CTCACTTCAT	AGATAACCAA	900
TTGTTTAATT	ATTCTTAGTC	CCTTATCTTA	TACTCCTAGT	AAGTGCTTAA	950
AAACTTG GTA	TAAATATCAA	ATTTATCGTA	CAATTACAAT	ATAATTATAA	1000
CGTATACCAT	GTAATTTTAA	AAACTATTTT	TAGATAAAAA	AAATATGGTG	1050
ATGAGCAGCC	GCAGCAGCGG	ACGCCGAACC	ACCTGCCGAA	CATCACCAAG	1100
ATAGCGAGTC	CTAAAAATTT	TTAGTGTTCC	TTTGCTGGGT	TGGTAACTAA	1150
TTAAAAAAA	AGAGCGACTC	ATTAGCTCAT	AAATAATTAC	GTATTAGCTA	1200
ATTTTTTTTAA	AAAATAAATT	AATATAACTT	ATAAAGCAGC	TTTTTGATATA	1250
TTTTTTTTTTT	AAAAAAGTGT	TGTTTAGCAG	TTTTGGGAAG	TGTGCCGAGG	1300
GAAAACGATG	AGATGGGTTG	GGGAAGGAGG	GGGAAGAAGT	GAAGAACACA	1350
GCAAATATAG	GCAGCATCGT	CCCGTACAGA	TCAGGCTGCA	ACCACGCCCC	1400

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GCGGAGATAG	TTAACGCGGC	CCACGTTGTG	CTATAGCCCG	TCACTCTCGC	1450
GGGCCTCTCC	AACCTCCAGT	TTTTTTTCTA	GCCCATCAGC	TGATACGGGG	1500
CCTTCCCCCC	ATGCAGGAGG	ATGGCCCGCC	ACGCGGTGTT	TTGGGCGGTT	1550
CTCGCCGCGC	GCGCCCGTGC	CGATCCGGGA	CTCATCCCAC	GTGCCGCCTC	1600
GCCACCGCCG	CCGCCGCGC	TGCTGCTCCG	GCTGCCGGCT	GGACCTTCAC	1650
GCTCACGCGC	TCTCCCCTGC	CCAACCACCA	CGCAAACAAA	CACGAAGTTC	1700
GCGCCGTCGA	CCGGCTCCCC	TCCTCCCCCG	CGCGCATCGG	ATCCCCCTAC	1750
ATAAACCCCTC	TCGCTCGCCA	TCGCCATGGC	AGCAACTCCC	CTCCTCCACT	1800
AGACCACCAT	GCACAGATCG	ATGGCCTCTC	AGGCGGTGGC	GCCCCCTCCTC	1850
CTCATCCTCA	TGCTCGCGGC	GGCGGCGGGG	GGCGCGTCGG	CGGCGGTGCA	1900
GTGCGGGCAG	GTGATGCAGC	TGATGGCGCC	GTGCATGCCG	TACCTCGCCG	1950
GCGCCCCCGG	GATGACGCCC	TACGGCATCT	GCTGCGACAG	CCTCGGCGTG	2000
CTCAACCGGA	TGGCCCCGGC	CCCCGCCGAC	CGCGTCGCCG	TCTGCAACTG	2050
CGTCAAGGAC	GCCGCCGCCG	GCTTCCCCCG	CGTCGACTTC	TCCCGCGCCT	2100
CCGCCCTCCC	CGCCGCCTGC	GGCCTCTCCA	TCAGCTTCAC	CATCGCCCCC	2150
AACATGGACT	GCAACCAGTA	AGTTCATTCA	TTCTTTCTTA	ACTCCAATTC	2200
AATTTATCCA	TCACCTCGAC	TTAAGCCTGA	TTAAACTTAA	CTTGTTCTTT	2250
GCATGCTTGC	ACTATTGCAG	GGTTACAGAG	GAAGTGAGAA	TCTGAGAGCG	2300
TGAGGAATCG	AGTTCATGTT	GCATTTATCA	TCAATCATCA	TCGACTAGAT	2350
CAATAAATCG	AGCAAAGCTT				2370

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9. Sequence Description : SEQ ID NO. 8

SEQUENCE TYPE: nucleotide sequence

SEQUENCE LENGTH: 2407 bp

STRANDEDNESS: double stranded

TOPOLOGY: linear

MOLECULAR TYPE: genomic DNA

ORIGINAL SOURCE:

ORGANISM: *Oryza sativa*

FEATURES: - nt 1 to nt 2263 : sequence comprising anther-specific PE1 promoter
 - nt 2181 to nt 2187 : TATA box
 - nt 2211 : transcription initiation site determined by primer extension
 - nt 2264 : ATG start of translation of E1 gene ; the sequence downstream from this position overlaps with the sequence of the cDNA of SEQ ID No. 5.

PROPERTIES: genomic DNA from *Oryza sativa* designated as GE1

TGATAGTGAC	ATACTCACAT	GCTTTGTCAA	TTCAAGTATC	AGTTCTTTTC	50
ATATTGATTT	CTTAGTTGAT	GAAAGTATAC	ATATTTCTTG	CCATCAATTC	100
TTTtagTAGG	TACATTTGGA	CACTAGTGGT	CAGGGTTGAA	CTCTTAAGTG	150
GAGTCTCATC	TGATTTGCTT	ATCTGAGACT	GGGTTTGTGC	AAATCCTGTC	200
ATGAGGCAAG	GTGGACTGTC	AGTCCATGAC	ACTTTGCTAC	TTCTATTAAAG	250
TTCTCGAAAT	CTTTTCCAGT	GTATGTCCGT	TCTCTTTCAA	ATGAATTATT	300
TATATGTTCT	GACAGCCTCG	CGGTGTACAT	TTCATTTAAC	TTTTGTCTTC	350
ACAGGGCCTC	TTGGTATTTT	GTTGAGCAGA	TTGGAATCAA	CCTTCTTGTA	400
GAACTTCTTG	ATGTCGTCGC	TACCTTTTGC	AACTAGATGG	TCAACTTCTG	450
TCTTATATCT	TTGGTACAAC	ACTGGCAAAG	TGTGCGCGCA	CAAGAATCCT	500
GTGAAGTAAG	AAATACAAAC	TTGTCAATTGT	GAAAGTTTAG	CTTTATATGA	550
TCTTGACTCT	AAATTGTTTC	TCCTCAGATC	CTTCTGTGTG	ATTGTTTTAT	600
TAAAATTTAA	TATTTATCTG	GAATACCTAC	CAATATATAG	TAGACTTGTC	650
AAGCTGCAAG	AACTTCCAAT	CGCCGACAAT	ACCAATAGAG	ATCCAACCAC	700
CTTAATATCA	TAAACAATCT	GATTGTTAGT	CCAGAACTAT	ATTGAGTAGT	750
GAACAACAAT	AGCACATTAA	CATTATGAGG	ATTATTGGCT	AACTCTGCAA	800
TTCAATATTC	TGATGCGTCT	AATCTGGTCA	ATTTTAGCGC	TCCAGAAAGA	850
ATTGCACAAT	CCTTGGACAA	TGTTGGCACT	GGAAGTGTG	CATGTTTTTA	900
CATCTCTTAT	TAACGTAGCA	AAGGAGTAGA	TTATTATGTA	CCAGGAGAAA	950
TCTCTTCAGA	TCCTTTCCAC	ATGCAATGTC	GTAAAGAACA	GATACAGTGT	1000
ACGTTAGTTT	GTAATGGACG	GTCAATGCCA	TTTCTCTGAA	GGCATGTTCA	1050
GAGATGATGA	TTTCTGGGAT	CCTTGGAGGG	GCCCTGAAAT	TCGGAAACAG	1100
TTAGTTGAGT	TTTAGTACCT	AATGTCTTGC	GTTATACTAC	GTGAAATGCC	1150
ATTTCTGTAA	GCTGAGTTT	CTACCATCTC	CACAGGAAAT	AAAGCTAATA	1200
CCTGTCCAAG	AGTGGTGCGG	CATTTGACCA	AATGAAGATC	ACAAGCATGG	1250
CAAGAATGGC	AATCTGGCAA	AGGAGCGGAA	TTATATTGTA	TTCTACTACA	1300
TCGAACAGGA	ACCATATCAA	TGTTGCCCCA	GCAAGGACCC	CCGCAGATAA	1350
GTTCCCTGTT	TTCCACAGCA	GAATATCCGC	AACTGCATAG	CTCCCAACAA	1400

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TGAAATCCAA	AACCACATCG	GCTCAGAGAG	AAGTTATGAT	AAAAGGCACT	1450
AATTCTGAAT	AATTTCCCTAG	AAAGCGAATA	ATAATAGCAC	ACCTTGACCT	1500
CCACCAAGAA	GCTTGTGGAT	CGACTTGTGC	CCATGAAATG	GCATTCTGAC	1550
ATTCTGGTCA	CTGTCAGAAT	CTCTCGGAAA	ATGAGGAGGC	ATAGCTTCGT	1600
GTGTGTATGT	GTGTGGGATA	TTACGCTGCT	AAAACTTTGT	GTTTCTGATC	1650
GATCTGGTTA	GAGAGCATCG	TCTTTATAAG	CACTTAAAAA	TGGTAGTATA	1700
ATCTCTCAAG	GAGCCTATAC	TGCCAAGGAA	AGGATAGCTT	GGCCTGTGGG	1750
GATTGAGCCG	TTGAAGGGAA	CAAACGAATA	CAGTTACCTT	ACCAGATGTT	1800
TGCCACGACA	TGGGCAACGT	CATTGCTAGA	CCAAGAAGGC	AAGAAGCAAA	1850
GTTTAGCTGT	CAAAAAAGAT	ATGCTAGAGG	CTTTCCAGAA	TATGTTCTAT	1900
CTCAGCCAGA	CCAATGGGGG	CAAAATTTAC	TACTATTTGC	CATACATTAA	1950
CCACGTAAAA	GTCCTACACT	CAACCTAACT	GTTGAACGGT	CCTGTTCTGG	2000
CCAACGGTGA	GAATGCACCT	AATGGACGGG	ACAACACTTC	TTTCACCGTG	2050
CTACTGCTAC	ATCCTGTAGA	CGGTGGACGC	GTGAGGTGCT	TTCGCCATGA	2100
CCGTCCTTGG	TTGTTGCAGT	CACTTGCGCA	CGCTTGCAAC	GTGACTCACC	2150
TGCCACATTG	CCCCCGCCGT	CGCCGGCGCC	TACAAAAGCC	ACACACGCAC	2200
GCCGGCCACG	ATAACCCATC	CTAGCATCCC	GGTGTCCAGC	AAGAGATCCA	2250
TCAAGCCGTC	GCGATGACGA	CGAGGCCTTC	TGTTTTTTCC	ACCGTTGTCT	2300
CGGCGATCGC	CATCGCCGCG	CTGCTGAGCA	GCCTCCTCCT	CCTGCAGGCT	2350
ACCCCGGCCG	CGGCCAGCGC	GAGGGCCTCG	AAGAAGGCTT	CGTGCGACCT	2400
GATGCAG					2407

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10. Sequence Description : SEQ ID NO. 9

SEQUENCE TYPE: nucleotide sequence

SEQUENCE LENGTH: 5620 bp

STRANDEDNESS: double stranded

TOPOLOGY: circular

MOLECULAR TYPE: plasmid DNA

FEATURES: - nt 1 to nt 395 : pUC18 derived sequence
 - nt 396 to nt 802 : 3' regulatory sequence containing the polyadenylation site derived from the nopaline synthase gene from Agrobacterium T-DNA
 - nt 803 to nt 1138 : coding sequence of the barnase gene
 - nt 1139 to nt 1683 : sequence derived from tapetum-specific promoter of Nicotiana tabacum
 - nt 1684 to nt 2516 : "35S3" promoter sequence derived from Cauliflower mosaic virus isolate CabbbB-JI
 - nt 2517 to nt 3068 : coding sequence of phosphinotricin acetyltransferase gene (bar)
 - nt 3069 to nt 3356 : 3' regulatory sequence containing the polyadenylation site derived from Agrobacterium T-DNA nopaline synthase gene
 - nt 3357 to nt 5620 : pUC18-derived sequence

PROPERTIES: plasmid DNA replicable in E. coli, designated as pVE108

TCGCGCGTTT	CGGTGATGAC	GGTGAAAACC	TCTGACACAT	GCAGCTCCCG	50
GAGACGGTCA	CAGCTTGTCT	GTAAGCGGAT	GCCGGGAGCA	GACAAGCCCG	100
TCAGGGCGCG	TCAGCGGGTG	TTGGCGGGTG	TCGGGGCTGG	CTTAACCTATG	150
CGGCATCAGA	GCAGATTGTA	CTGAGAGTGC	ACCATATGCG	GTGTGAAATA	200
CCGCACAGAT	GCGTAAGGAG	AAAATACCGC	ATCAGGCGCC	ATTCGCCATT	250
CAGGCTGCGC	AACTGTTGGG	AAGGGCGATC	GGTGCGGGCC	TCTTCGCTAT	300
TACGCCAGCT	GGCGAAAGGG	GGATGTGCTG	CAAGGCGATT	AAGTTGGGTA	350
ACGCCAGGGT	TTTCCCAGTC	ACGACGTTGT	AAAACGACGG	CCAGTGAATT	400
CGAGCTCGGT	ACCCGGGGAT	CTTCCCGATC	TAGTAACATA	GATGACACCG	450
CGCGCGATAA	TTTATCCTAG	TTTGCGCGCT	ATATTTTGTT	TTCTATCGCG	500
TATTAAATGT	ATAATTGCCG	GACTCTAATC	ATAAAAACCC	ATCTCATAAA	550
TAACGTCATG	CATTACATGT	TAATTATTAC	ATGCTTAACG	TAATTCAACA	600
GAAATTATAT	GATAATCATC	GCAAGACCGG	CAACAGGATT	CAATCTTAAG	650
AAACTTTATT	GCCAAATGTT	TGAACGATCT	GCTTCGGATC	CTCTAGAGXX	700
XXCCGGAAAG	TGAAATTGAC	CGATCAGAGT	TTGAAGAAAA	ATTTATTACA	750
CACTTTATGT	AAAGCTGAAA	AAAACGGCCT	CCGCAGGAAG	CCGTTTTTTT	800
CGTTATCTGA	TTTTTGTAAG	GGTCTGATAA	TGGTCCGTTG	TTTTGTAAAT	850
CAGCCAGTCG	CTTGAGTAAA	GAATCCGGTC	TGAATTTCTG	AAGCCTGATG	900
TATAGTTAAT	ATCCGCTTCA	CGCCATGTTC	GTCCGCTTTT	GCCCGGGAGT	950
TTGCCTTCCC	TGTTTGAGAA	GATGTCTCCG	CCGATGCTTT	TCCCCGGAGC	1000
GACGTCTGCA	AGGTTCCCTT	TTGATGCCAC	CCAGCCGAGG	GCTTGTGCTT	1050
CTGATTTTGT	AATGTAATTA	TCAGGTAGCT	TATGATATGT	CTGAAGATAA	1100
TCCGCAACCC	CGTCAAACGT	GTTGATAACC	GGTACCATGG	TAGCTAATTT	1150

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CTTTAAGTAA	AAACTTTGAT	TTGAGTGATG	ATGTTGTACT	GTTACACTTG	1200
CACCACAAGG	GCATATATAG	AGCACAAAGAC	ATACACAACA	ACTTGCAAAA	1250
CTAACTTTTG	TTGGAGCATT	TCGAGGAAAA	TGGGGAGTAG	CAGGCTAATC	1300
TGAGGGTAAC	ATTAAGGTTT	CATGTATTAA	TTTGTGTCAG	ACATGGACTT	1350
AGTGTGAGGA	AAAAGTACCA	AAATTTTGTG	TCACCCTGAT	TTCAGTTATG	1400
GAAATTACAT	TATGAAGCTG	TGCTAGAGAA	GATGTTTATT	CTAGTCCAGC	1450
CACCCACCTT	ATGCAAGTCT	GCTTTTAGCT	TGATTCAAAA	ACTGATTTAA	1500
TTTACATTGC	TAAATGTGCA	TACTTCGAGC	CTATGTCGCT	TTAATTCGAG	1550
TAGGATGTAT	ATATTAGTAC	ATAAAAAATC	ATGTTTGAAT	CATCTTTCAT	1600
AAAGTGACAA	GTCAATTGTC	CCTTCTTGTT	TGGCACTATA	TTCAATCTGT	1650
TAATGCAAAT	TATCCAGTTA	TACTTAGCTA	GATCCTACGC	AGCAGGTCTC	1700
ATCAAGACGA	TCTACCCGAG	TAACAATCTC	CAGGAGATCA	AATACCTTCC	1750
CAAGAAGGTT	AAAGATGCAG	TCAAAAGATT	CAGGACTAAT	TGCATCAAGA	1800
ACACAGAGAA	AGACATATTT	CTCAAGATCA	GAAGTACTAT	TCCAGTATGG	1850
ACGATTCAAG	GCTTGCTTCA	TAAACCAAGG	CAAGTAATAG	AGATTGGAGT	1900
CTCTAAAAAG	GTAGTTCCTA	CTGAATCTAA	GGCCATGCAT	GGAGTCTAAG	1950
ATTCAAATCG	AGGATCTAAC	AGAACTCGCC	GTGAAGACTG	GCGAACAGTT	2000
CATACAGAGT	CTTTTACGAC	TCAATGACAA	GAAGAAAATC	TTCGTCAACA	2050
TGGTGGAGCA	CGACACTCTG	GTCTACTCCA	AAAATGTCAA	AGATACAGTC	2100
TCAGAAGACC	AAAGGGCTAT	TGAGACTTTT	CAACAAAGGA	TAATTTCTGGG	2150
AAACCTCCTC	GGATTCCATT	GCCCAGCTAT	CTGTCACTTC	ATCGAAAGGA	2200
CAGTAGAAAA	GGAAGGTGGC	TCCTACAAAT	GCCATCATTG	CGATAAAGGA	2250
AAGGCTATCA	TTCAAGATGC	CTCTGCCGAC	AGTGGTCCCA	AAGATGGACC	2300
CCCACCCACG	AGGAGCATCG	TGGAAAAAGA	AGACGTTCCA	ACCACGTCTT	2350
CAAAGCAAGT	GGATTGATGT	GACATCTCCA	CTGACGTAAG	GGATGACGCA	2400
CAATCCCACT	ATCCTTCGCA	AGACCCTTCC	TCTATATAAG	GAAGTTCATT	2450
TCATTTGGAG	AGGACACGCT	GAAATCACCA	GTCTCTCTCT	ATAAATCTAT	2500
CTCTCTCTCT	ATAACCATGG	ACCCAGAACG	ACGCCCGGCC	GACATCCGCC	2550
GTGCCACCGA	GGCGGACATG	CCGGCGGTCT	GCACCATCGT	CAACCACTAC	2600
ATCGAGACAA	GCACGGTCAA	CTTCCGTACC	GAGCCGCAGG	AACCGCAGGA	2650
GTGGACGGAC	GACCTCGTCC	GTCTGCGGGA	GCGCTATCCC	TGGCTCGTCG	2700
CCGAGGTGGA	CGGCGAGGTC	GCCGGCATCG	CCTACGCGGG	CCCCTGGAAG	2750
GCACGCAACG	CCTACGACTG	GACGGCCGAG	TCGACCGTGT	ACGTCTCCCC	2800
CCGCCACCAG	CGGACGGGAC	TGGGCTCCAC	GCTCTACACC	CACCTGCTGA	2850
AGTCCCTGGA	GGCACAGGGC	TTCAAGAGCG	TGGTCTGCTG	CATCGGGCTG	2900
CCCAACGACC	CGAGCGTGCG	CATGCACGAG	GCGCTCGGAT	ATGCCCCCGG	2950
CGGCATGCTG	CGGGCGGGCC	GCTTCAAGCA	CGGGAAGTGG	CATGACGTGG	3000
GTTTCTGGCA	GCTGGACTTC	AGCCTGCCGG	TACCGCCCCG	TCCGGTCTCTG	3050
CCCGTCACCG	AGATCTGATC	TCACGCGTCT	AGGATCCGAA	GCAGATCGTT	3100
CAAACATTTG	GCAATAAAGT	TTCTTAAGAT	TGAATCCTGT	TGCCGGTCTT	3150
GCGATGATTA	TCATATAATT	TCTGTTGAAT	TACGTTAAGC	ATGTAATAAT	3200
TAACATGTAA	TGCATGACGT	TATTTATGAG	ATGGGTTTTT	ATGATTAGAG	3250
TCCCGCAATT	ATACATTTAA	TACGCGATAG	AAAACAAAAT	ATAGCGCGCA	3300
AACTAGGATA	AATTATCGCG	CGCGGTGTCA	TCTATGTTAC	TAGATCGGGA	3350
AGATCCTCTA	GAGTCGACCT	GCAGGCATGC	AAGCTTGCGG	TAATCATGGT	3400
CATAGCTGTT	TCCTGTGTGA	AATTGTTATC	CGCTCACAAT	TCCACACAAC	3450
ATACGAGCCG	GAAGCATAAA	GTGTAAAGCC	TGGGGTGCCT	AATGAGTGAG	3500
CTAACTCACA	TTAATTGCGT	TGCGCTCACT	GCCCGCTTTC	CAGTCGGGAA	3550
ACCTGTCGTG	CCAGCTGCAT	TAATGAATCG	GCCAACGCGC	GGGGAGAGGC	3600
GGTTTGCGTA	TTGGGCGCTC	TTCCGCTTCC	TCGCTCACTG	ACTCGCTGCG	3650
CTCGGTCGTT	CGGCTGCGGC	GAGCGGTATC	AGCTCACTCA	AAGGCGGTAA	3700
TACGGTTATC	CACAGAATCA	GGGGATAACG	CAGGAAAGAA	CATGTGAGCA	3750

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AAAGGCCAGC	AAAAGGCCAG	GAACCGTAAA	AAGGCCGCGT	TGCTGGCGTT	3800
TTTCCATAGG	CTCCGCCCCC	CTGACGAGCA	TCACAAAAAT	CGACGCTCAA	3850
GTCAGAGGTG	GCGAAACCCG	ACAGGACTAT	AAAGATACCA	GGCGTTTCCC	3900
CCTGGAAGCT	CCCTCGTGCG	CTCTCCTGTT	CCGACCCTGC	CGCTTACCGG	3950
ATACCTGTCC	GCCTTTCTCC	CTTCGGGAAG	CGTGGCGCTT	TCTCAATGCT	4000
CACGCTGTAG	GTATCTCAGT	TCGGTGTAGG	TCGTTTCGCTC	CAAGCTGGGC	4050
TGTGTGCACG	AACCCCCCGT	TCAGCCCGAC	CGCTGCGCCT	TATCCGGTAA	4100
CTATCGTCTT	GAGTCCAACC	CGGTAAGACA	CGACTTATCG	CCACTGGCAG	4150
CAGCCACTGG	TAACAGGATT	AGCAGAGCGA	GGTATGTAGG	CGGTGCTACA	4200
GAGTTCTTGA	AGTGGTGGCC	TAAGTACGGC	TACACTAGAA	GGACAGTATT	4250
TGGTATCTGC	GCTCTGCTGA	AGCCAGTTAC	CTTCGGAAAA	AGAGTTGGTA	4300
GCTCTTGATC	CGGCAAACAA	ACCACCGCTG	GTAGCGGTGG	TTTTTTTGT	4350
TGCAAGCAGC	AGATTACGCG	CAGAAAAAAA	GGATCTCAAG	AAGATCCTTT	4400
GATCTTTTCT	ACGGGGTCTG	ACGCTCAGTG	GAACGAAAAC	TCACGTTAAG	4450
GGATTTTGGT	CATGAGATTA	TCAAAAAGGA	TCTTCACCTA	GATCCTTTTA	4500
AATTAAAAAT	GAAGTTTTAA	ATCAATCTAA	AGTATATATG	AGTAAACTTG	4550
GTCTGACAGT	TACCAATGCT	TAATCAGTGA	GGCACCTATC	TCAGCGATCT	4600
GTCTATTTTC	TTCATCCATA	GTTGCCTGAC	TCCCCGTCGT	GTAGATAACT	4650
ACGATACGGG	AGGGCTTACC	ATCTGGCCCC	AGTGCTGCAA	TGATACCGCG	4700
AGACCCACGC	TCACCGGCTC	CAGATTTATC	AGCAATAAAC	CAGCCAGCCG	4750
GAAGGGCCGA	GCGCAGAAGT	GGTCCTGCAA	CTTTATCCGC	CTCCATCCAG	4800
TCTATTAATT	GTTGCCGGGA	AGCTAGAGTA	AGTAGTTCCG	CAGTTAATAG	4850
TTTGCGCAAC	GTTGTTGCCA	TTGCTACAGG	CATCGTGGTG	TCACGCTCGT	4900
CGTTTGGTAT	GGCTTCATTC	AGCTCCGGTT	CCCAACGATC	AAGGCGAGTT	4950
ACATGATCCC	CCATGTTGTG	CAAAAAAGCG	GTTAGCTCCT	TCGGTCCTCC	5000
GATCGTTGTC	AGAAGTAAGT	TGGCCGCACT	GTTATCACTC	ATGGTTATGG	5050
CAGCACTGCA	TAATTCTCTT	ACTGTCATGC	CATCCGTAAG	ATGCTTTTCT	5100
GTGACTGGTG	AGTACTCAAC	CAAGTCATTC	TGAGAATAGT	GTATGCGGCG	5150
ACCGAGTTGC	TCTTGCCCGG	CGTCAATACG	GGATAATACC	GCGCCACATA	5200
GCAGAACTTT	AAAAGTGCTC	ATCATTGGAA	AACGTTCTTC	GGGGCGAAAA	5250
CTCTCAAGGA	TCTTACCGCT	GTTGAGATCC	AGTTCGATGT	AACCCACTCG	5300
TGCACCCAAC	TGATCTTCAG	CATCTTTTAC	TTTCACCAGC	GTTTCTGGGT	5350
GAGCAAAAAC	AGGAAGGCAA	AATGCCGCAA	AAAAGGGAAT	AAGGGCGACA	5400
CGGAAATGTT	GAATACTCAT	ACTCTTCCTT	TTTCAATATT	ATTGAAGCAT	5450
TTATCAGGGT	TATTGTCTCA	TGAGCGGATA	CATATTTGAA	TGTATTTAGA	5500
AAAATAAACA	AATAGGGGTT	CCGCGCACAT	TTCCCCGAAA	AGTGCCACCT	5550
GACGTCTAAG	AAACCATTAT	TATCATGACA	TTAACCTATA	AAAATAGGCG	5600
TATCACGAGG	CCCTTTCGTC				5620

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CLAIMS

1. A stamen-specific plant promoter which can be isolated from genomic rice DNA, upstream of a gene having a DNA sequence which corresponds to T72 cDNA of SEQ ID no. 1, T23 cDNA of SEQ ID no. 2, T42 cDNA of SEQ ID no. 3, T155 cDNA of SEQ ID no. 4 or E1 cDNA, of SEQ ID no. 5, especially the T72 cDNA, particularly the promoter PT72 upstream from nucleotide 2846 of SEQ ID no. 6, the promoter PT42 upstream from nucleotide 1809 of SEQ ID no. 7, and the promoter PE1 upstream from nucleotide 2264 of SEQ ID no. 8.
2. A foreign, preferably chimaeric, DNA sequence suitable for transforming a plant, which comprises the promoter of claim 1 and a structural gene under the control of the promoter.
3. The foreign DNA sequence of claim 2 wherein the structural gene is a male-sterility DNA or a male fertility-restorer DNA.
4. The foreign DNA sequence of claim 2 or 3 which is a foreign chimaeric DNA sequence.
5. A plant cell or plant cell culture transformed with the foreign DNA sequence of anyone of claims 2-4.
6. A plant or its seeds consisting essentially of the plant cells of claim 5.
7. The genome of the plant of claim 6 containing the foreign DNA sequence of any one of claims 2-4.
8. A male-sterile plant of claim 6 in which the structural gene is a male-sterility DNA.

9. A fertility-restorer plant of claim 6 in which the structural gene is a male fertility-restorer DNA.

10. A male fertility-restored plant which is a hybrid of the male-sterile plant of claim 8 and the male fertility-restorer plant of claim 9 or the seeds of the male fertility-restored plant.


11. The plant of anyone of claims 6-10 which is a monocot.

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INTERNATIONAL SEARCH REPORT

International Application No

PCT/EP 92/00274

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all) ⁶		
According to International Patent Classification (IPC) or to both National Classification and IPC		
Int.Cl. 5	C12N15/82;	C12N15/29; A01H5/00; C12N5/10
II. FIELDS SEARCHED		
Minimum Documentation Searched ⁷		
Classification System	Classification Symbols	
Int.Cl. 5	C12N ; A01H	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁸		
III. DOCUMENTS CONSIDERED TO BE RELEVANT⁹		
Category [*]	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³
A	WO,A,9 008 830 (ICI) 9 August 1990 see the whole document ---	1-11
A	EP,A,0 344 029 (PLANT GENETIC SYSTEMS) 29 November 1989 see the whole document ---	1-11
A	Biological Abstracts, vol.87, ref.125906 & J.CELL SCI. vol. 92, no. 2, 1989, pages 217 - 230; RAGHAVAN, V.: 'Messenger RNAs and a cloned histone gene are differentially expressed during anther development in rice Oryza sativa L.' see the abstract --- -/-	1-11
<p>[*] Special categories of cited documents : ¹⁰</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"A" document member of the same patent family</p>		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report	
06 MAY 1992	20. 05. 92	
International Searching Authority	Signature of Authorized Officer	
EUROPEAN PATENT OFFICE	MADDOX A.D. 	

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category *	Citation of Document, with indication, where appropriate, of the relevant passages	Relevant to Claim No.
A	J. CELL. BIOCHEM. SUPPL. vol. 15A, 1991, MEETING HELD JAN. 10-17 page 21; MARIANI, C., ET AL.: 'Genetic destruction of tapetal cells results in the production of male sterile plants' abstract A039 ---	9,10
A	WO,A,9 008 828 (PALADIN HYBRIDS) 9 August 1990 see page 39, line 25 - page 48, line 31 ---	9,10

**ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO. EP 9200274
SA 55868**

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information. 06/05/92

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO-A-9008830	09-08-90	AU-B- 621195	05-03-92
		AU-A- 4945690	24-08-90
		EP-A- 0455665	13-11-91
EP-A-0344029	29-11-89	AU-B- 621113	05-03-92
		AU-A- 3537189	24-11-89
		WO-A- 8910396	02-11-89
		JP-T- 2503988	22-11-90
WO-A-9008828	09-08-90	AU-A- 5037290	24-08-90
		EP-A- 0456706	21-11-91

EPO FORM P007Y

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82